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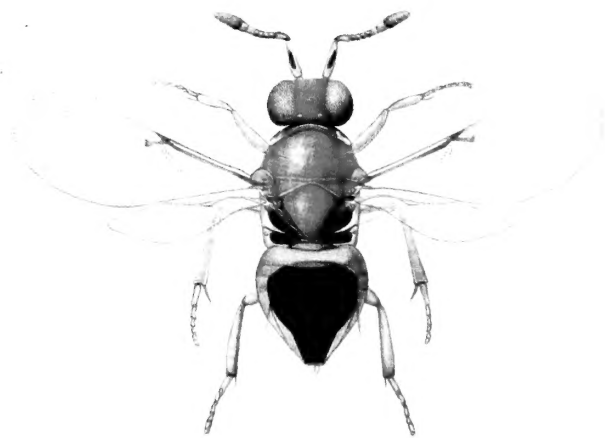
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Figs 1-3 *Metaphycus electra* ♂ - 1; *Sectiliclava isis* ♂ - 2; *Psyllaephagus trioziphagus* ♀ - 3.

Encyrtidae (Hymenoptera:
Chalcidoidea) of Costa Rica: the
genera and species associated with
jumping plant-lice (Homoptera:
Psylloidea).

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SYNOPSIS. Eight genera and 26 species of encyrtids found in association with jumping plant lice (Psylloidea) in Costa Rica are reviewed. Three genera are recorded for the first time from the Neotropical region, and one genus and 21 species are described as new. Dichotomous keys to all genera and species are provided, each species is further characterised by a diagnosis and notes are provided on distribution and host associations where known.

INTRODUCTION

Alarming rates of deforestation in tropical countries have generated considerable interest in reforestation projects utilising native trees (Butterfield, 1994).

Such projects normally devote large areas to relatively few tree species in order to make plantations easier to manage. The resulting increased density of individual tree species will inevitably heighten the risk of plantation trees being severely damaged by outbreaks of indigenous tree-feeding insect groups.

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One such group of potential forestry pests, the jumping plant-lice or Psyllodea, is particularly species rich in Neotropical forests and in Costa Rica species are known to feed on several important native tree genera, eg. *Alaroea*, *Cedrela*, *Haematoxylum*, *Hymenaea*, *Inga*, *Lonchocarpus*, *Pentaclethra* and *Virola* (D. Hollis, pers. comm.). The use of pesticides to control new forest pests may prove to be ineffective, uneconomic or environmentally unsound and therefore other control measures, such as biological control, will be required. A taxonomic study of the existing parasitoids of psyllids will provide the necessary foundation for biological control of these potential pests. One group of parasitoids of particular importance is the chalcidoid family Encyrtidae (Hymenoptera; Chalcidoidea) because it includes many species which are specialist primary parasitoids of jumping plant-lice. At least one Costa Rican species, *Psyllaephagus yaseeni* Noyes, has been introduced into various countries from Hawaii to the Indian subcontinent in order to aid in the control of *Heteropsylla cubana* Crawford, a pest of *Leucaena leucocephala* (see below). This plant is important as cattle fodder, green manure, a shade plant for coffee and cocoa and as a nitrogen fixing plant in alley cropping.

In addition to their use in biological control, psyllid parasitoids may be useful for studies in host specialisation or perhaps even co-evolution. Species in some taxa, such as *Psyllaephagus*, appear to have specialised and diversified on psyllids whereas others, such as a few species of *Metaphycus*, appear to have switched from their normal scale-insect hosts (Homoptera: Coccoidea) to psyllids. Further to this, psyllids that induce gall formation seem to be attacked primarily by two sets of parasitoids: those that specialise on psyllid hosts and those that generally attack gall-forming hosts.

As a result of recent field work in Costa Rica several species of encyrtid parasitoids have been reared from jumping plant-lice and their galls. Most are primary parasitoids of psyllids, whilst some are parasitoids of insects otherwise associated with psyllid galls, eg. parasitoids of coccinellid larvae feeding on gall-forming psyllids. Additional material, belonging to these encyrtid groups, has also been made available through the extensive Malaise trapping programme undertaken in Costa Rica since 1985 (see Noyes & Ren Hui, 1995). The present study thus directly results from this work and is intended to facilitate the identification of Encyrtidae that may be reared from psyllids or their galls in Costa Rica, or adjacent areas. It is the second in a series that is aimed at eventually revising all Costa Rican Encyrtidae.

DEPOSITORIES

CNC	Canadian National Collection, Ottawa, Canada
BMNH	The Natural History Museum, London, UK
INBio	Instituto Nacional de Biodiversidad, Costa Rica
NMHS	Naturhistoriska Riksmuseet, Stockholm, Sweden
NMID	National Museum of Ireland, Dublin, Eire
UCR	Museo de Insectos, University of Costa Rica, Costa Rica
USNM	United States National Museum, Washington D.C., USA

ACKNOWLEDGEMENTS. We thank Dr M.E. Schauff (USNM), Dr L. Masner (CNC) and Dr J. Huber (CNC) for the loan or gift of material. Our special thanks go to Pam Mitchell for her painstaking sorting of Malaise trap catches from Santa Rosa National Park. Dave Hollis (NHM) helped us by checking the psyllid names and several friends and colleagues provided us with information relating to multiple species rearings from a single host species, although not all examples were used (Jacques van Alphen, Lex Kraaijeveld, John LaSalle, Andrew Polaszek, David Rosen, Jim Woolley and Bob Zuparko). We would like to thank Aldo de Oyarzabal for the colour illustration of *Psyllaephagus triocephalus*, *Sectiliclava isis* and *Metaphycus electra* (Figs 1–3). Finally, we would like to acknowledge financial support for this work from the Vicerrectoria de Investigaciones of the Universidad de Costa Rica.

ABBREVIATIONS USED IN TEXT

AL	length of aedeagus
CL	length of costal cell of forewing
CW	maximum width of costal cell of forewing
F1, F2, etc.	first funicle segment, second funicle segment, etc.
EL	maximum eye length
EW	maximum eye width
FV	minimum frontovertex width
FWL	forewing length
FWW	forewing width
GL	maximum length of gonostylus (or third valvula)
HI	depth of incised part of posterior margin of hypopygium
HW	head width
HWL	hindwing length
HWW	hindwing width
MS	malar space (the shortest distance from the eye to mouth margin)
MT	mid tibia length
MTS	mid tibial spur length
OL	ovipositor length
OOL	ocular-ocellar line, or the shortest distance

	between each posterior ocellus and the adjacent eye margin
POL	posterior ocellar line, or the shortest distance between the two posterior ocelli
SL	scape length (excluding radicle)
SW	maximum scape width

Key to Costa Rican genera of Encyrtidae associated with psylloids or their galls

- 1 Antennae with fewer than 6 funicle segments 2
- Antennae with 6 funicle segments 3
- 2 Antennae with 4 funicle segments *Cercobelus* (p. 107)
- Antennae with 5 funicle segments *Trechnites* (p. 112)
- 3 Mesoscutum with notaular lines complete; forewing with stigmal vein abruptly bent below marginal vein (Fig. 28) *Homalotylus* (p. 113)
- Notaular lines absent or not reaching more than half way across mesoscutum; forewing with stigmal vein straight or slightly curved, not abruptly bent below marginal vein 4
- 4 Forewings with marginal vein at least 3 × as long as broad (Fig. 31) *Caldencyrtus* (p. 114)
- Marginal vein not more than 2 × as long as broad, mostly punctiform or absent (Figs 37, 39, 40, 43, 47, etc.) 5
- 5 Mandibles tridentate (Fig. 132); head and thorax yellow to dark brown without metallic blue, green or purple lustre *Metaphycus* (p. 118)
- Mandibles with one or two teeth and a truncation (Figs 138, 139, 143–146), four teeth (Fig. 133), or more or less edentate (Fig. 137); head and thorax with at least a slight metallic green, blue or purple lustre 6
- 6 Apical segment of foretarsus enlarged, nearly as long as remaining segments together and at least twice as wide (Fig. 2) *Sectiliclava* (p. 121)
- Apical segment of foretarsus not enlarged, or hardly so, less than half as long as remaining segments of tarsus and not more than 1.5 × as wide 7
- 7 Postero-lateral margin of mesoscutum, anterior to each tegula, with a deep, distinct submarginal indentation which is about as wide as the tegula. FEMALE: hypopygium reaching past apex of last tergite of gaster and enclosing most of ovipositor *Prionomitus* (p. 123)
- Mesoscutum without an indentation anterior to the tegulae, sometimes with a shallow impression adjacent to the antero-lateral margins. FEMALE: hypopygium not reaching apex of gaster *Psyllaephagus* (p. 125)

CERCOBELUS Walker

Cercobelus Walker, 1842: vi. Type species *Cercobelus jugaeus* Walker, by monotypy.

DIAGNOSTIC CHARACTERS. Female. Antenna inserted close to mouth margin and with funicle 4-segmented and clava 3-segmented; head oval or spherical in facial view with eyes relatively small, not longer than minimum width of frontovertex, or hardly so; inner eye margins slightly emarginate; occipital margin sharp; mandibles with one very small tooth and a broad truncation or three or four very short, obtuse teeth; forewings with marginal vein varying from very short, almost absent, to at least twice as long as broad; postmarginal vein almost absent; setae in basal cell much less dense than in disc; gaster, somewhat elongate and with segments telescopic, the ovipositor short and not more than 0.5 × as long as mid tibia, or hardly so; ovipositor with a unique, highly modified structure. Male. Similar to female, but antenna usually with segments relatively slightly longer and clothed in setae which are longer than diameter of segments; clava entire; genitalia with aedeagus apically very acute and digiti distinct but relatively slender and apically armed with a pair of hooks.

BIOLOGY. The only previously known species, the European *C. jugaeus* (Walker), has been recorded as a parasitoid of *Psyllopsis fraxinicola* Förster, *P. fraxini* Linnaeus and *Psyllopsis proprius* Loginova (Homoptera: Psyllidae) (see Trjapitzin, 1989).

DISTRIBUTION. Although the genus is probably cosmopolitan, in the New World it has only been found in Mexico and Costa Rica and has yet to be found in the eastern Palaearctic.

IDENTIFICATION OF SPECIES. Other than the five species described below, there is only a single described species from Europe (*jugaeus* Walker) and several undescribed species from Mexico, Africa, India, Sarawak and Australia (material in BMNH, TAMU, see also Noyes & Hayat, 1984).

Key to Costa Rican species of Cercobelus

- 1 Clava 3-segmented (females) 2
- Clava entire (males) 6
- FEMALES
- 2 F2–F4 transverse or quadrate 3
- F2–F4 clearly longer than broad 4
- 3 Forewings only lightly infusate below apex of venation (Fig. 5); F1 transverse, clava about as long as funicle (Fig. 4) *isara* (p. 108)

- Forewings with a conspicuous interrupted transverse fascia from apex of venation and an elongate, dark brown, wedge-shaped mark to apex (Fig. 10); F1 slightly longer than broad, clava about as long as F2–F4 combined (Fig. 9) *sithon* (p. 109)
- 4 Pronotum very long and clearly longer than mesoscutum medially; marginal vein of forewing at least 3 × as long as broad (Fig. 16) *ulixes* (p. 110)
- Pronotum moderately long, but clearly shorter than mesoscutum medially; marginal vein of forewing not longer than broad (Fig. 19) 5
- 5 Propodeum with two, posteriorly diverging, median carinae; mid legs extensively marked with brown *godoyae* (p. 110)
- Propodeum with only a single median carina; mid legs yellow, with mid tibiae hardly brownish basally *daphne* (p. 111)

MALES

- 6 Forewings hyaline without even an inconspicuous infusate pattern *isara* (p. 108)
- Forewings with an infusate pattern in apical half 7
- 7 Setae on funicle at least twice as long as diameter of funicle segments (Fig. 21) *sithon* (p. 109)
- Setae on funicle at most about as long as diameter of funicle segments *ulixes* (p. 110)

Cercobelus isara sp. nov.

(Figs 4–8, 100–102)

DIAGNOSIS. Female (length 1.30–1.41 mm): all funicle segments transverse and clava about as long as funicle (Fig. 4); mandibles with one very small lower tooth and a very broad, finely serrated truncation (Fig. 101); mesoscutum at least 3 × as long as pronotum medially in dorsal view; forewings slightly infusate below stigmal vein and with apical one-third inconspicuously infusate (Fig. 5); marginal vein very slightly longer than broad and touching anterior wing margin (Fig. 7); propodeum about one-fifth as long as scutellum; gaster slightly shorter than thorax; ovipositor slightly more than one-third length of mid tibia. Male (length about 1.90 mm): similar to female, but all funicle segments longer than broad and clothed in setae that are longer than diameter of segments (Fig. 8); aedeagus about half length of mid tibia.

FEMALE (HOLOTYPE). Length 1.35 mm. Head generally blackish with purple lustre, ocellar area greenish; mesoscutum similar but with a green lustre, margins purplish; scutellum and axillae mostly with coppery purple lustre; antenna with scape dark brown, pedicel dark brown with apex testaceous, flagellum testaceous-yellow, clava slightly darker apically; wings mostly hyaline but with a weakly infusate area below the stigmal vein and apical one-third or so very weakly

infusate; coxae and femora very dark brown; fore tibia dark brown, except extreme apex which is yellowish; fore tarsus with basal three segments yellowish apical segments brown; mid tibia with basal two-thirds dark brown, apical one-third yellow; mid tibial spur pale yellow; mid tarsus yellow with apical segment brown; hind tibia dark brown with basal one-third yellow; hind tarsus dark brown; gaster dark brown, basal tergite with a slight purple and green sheen.

Head with fairly regular, raised reticulate sculpture on frontovertex of mesh slightly larger than an eye facet, sculpture becoming more elongate and less regular on lower parts of face and genae; mandibles with one very small lower tooth and a very broad, finely serrated truncation (Fig. 101); inner margins of eyes slightly sinuate; eyes inconspicuously hairy and separated from occipital margin by about the longitudinal diameter of a posterior ocellus; ocelli forming a strongly obtuse angle; occipital margin sharply carinate; transverse midline of antennal toruli level with lowest eye margins; proportions of antennae as in Fig. 4. Relative measurements: HW 72; FV 44; POL 19; OOL 10; OCL 5; EL 38; EW 25; MS 22; SL 28; SW 8.

Mesoscutum with fairly regular raised, reticulate sculpture, slightly deeper than that on frontovertex, anteriorly tending to imbricate-reticulate; scutellum with similar, but more shallow sculpture, especially at apex which is almost smooth; mesoscutum about 1.5 × as broad as long and at least three times as long as pronotum medially in dorsal view; venation and distribution of setae at base of forewing as in Figs 6 and 7; costal cell about 10 × as long as broad; mid tibial spur long and slender, nearly 10 × as long as broad; hind tibia slightly broadened and flattened, about 4.5 × as long as broad. Relative measurements: FWL 209, FWW 80; HWL 133, HWW 35.

Gaster slightly shorter than the thorax; ovipositor (Fig. 100) slightly exerted at apex; last tergite clearly constricted subapically and with apex broadly concave and truncate. Relative measurements (paratype): OL 19; GL 5 [MT 59].

MALE. Very similar to female except for antenna (Fig. 8) and genitalia (Fig. 102). Relative measurements: FV 30, SL 18; MT 59, AL 29.

VARIATION. Very little in available material.

HOSTS. Unknown.

DISTRIBUTION. Costa Rica.

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, Puntarenas, San Vito, Est. Las Alturas, 1500m, i.1992 (P. Hanson) (BMNH). Paratypes: 1♂, Guanacaste, Volcán Cacao, Cerro Pedregal, 1000m, ii–iv.1989 (I.D. Gauld); 1♂, same data as holotype but xi.1991 (P. Hanson, C. Godoy); 1♂, same data as holotype; 2♀, San José, Zurquí de

Moravia, 1600m, iii.1992 and v.1994 (P. Hanson). Paratypes in BMNH, INBio.

COMMENTS. *Cercobelus isara* can be separated from other described species of the genus by the relatively short funicle segments, all other described species having the funicle segments distinctly longer than broad. It is very similar to an undescribed species from Mexico (BMNH, TAMU) which also has relatively short funicle segments and similar mandibular structure, but in that species the segments are very slightly longer than broad and the antenna are clearly inserted below the level of the lowest eye margins.

Cercobelus sithon sp. nov.

(Figs 9–12, 20, 21, 105, 106)

DIAGNOSIS. Female (length 1.90mm): F1 slightly longer than broad, F2–F4 quadrate; clava about as long as F2–F4 combined (Fig. 9); mesoscutum about one-third longer than pronotum medially in dorsal view; forewings with an interrupted, dark brown fascia from stigmal vein to posterior margin and with an elongate wedge-shaped dark brown mark beyond this to wing apex (Fig. 10); marginal vein punctiform and touching anterior wing margin (Fig. 12); propodeum about one-third as long as scutellum; gaster slightly shorter than thorax. Male (length 1.80–2.00mm): antenna with all funicle segments longer than broad and clothed in setae with are at least twice as long as diameter of segments (Fig. 21); otherwise similar to female.

FEMALE (HOLOTYPE). Head, pronotum and mesoscutum generally blackish with a green lustre, mixed slightly brassy and coppery, occipital margin purple; scutellum and axillae mostly with coppery purple lustre; antenna with scape pale amber, pedicel dark brown with apex testaceous, flagellum testaceous-brown; forewing (Fig. 10) with base hyaline to distal margin of linea calva, an interrupted transverse brown fascia from postmarginal and stigmal veins to hind wing margin and an elongate, dark brown, wedge shaped mark from centre of wing to apex; fore legs pale amber, fore coxae with a small, external dark brown mark; mid coxae dark brown, remainder of mid legs pale amber but for extreme bases of tibiae which are brown and beyond this white; hind legs with coxae and basal two-thirds of femora pale amber, apices of femora and apical three-quarters of tibiae dark brown, basal part of tibiae and most of tarsi white, apical tarsal segment dark brown; gaster dark purple-brown.

Head with fairly regular, raised reticulate sculpture on frontovertex of mesh slightly larger than an eye facet, sculpture becoming more elongate and less regular on lower parts of face and genae; inner margins of eyes slightly sinuate; eyes inconspicuously hairy and

separated from occipital margin by about the longitudinal diameter of a posterior ocellus; ocelli forming a strongly obtuse angle; occipital margin sharply carinate; transverse midline of antennal toruli about level with lowest eye margins; proportions of antennae as in Fig. 9. Relative measurements: HW 90; FV 57; POL 29; OOL 13; OCL 8; EL 46; EW 30; MS 21; SL 37; SW 8.5.

Mesoscutum with fairly regular raised, reticulate sculpture, similar to frontovertex; scutellum with similar, but more shallow sculpture, especially at apex which is almost smooth; mesoscutum about $1.5 \times$ as broad as long and about one-third longer than pronotum medially in dorsal view; venation and distribution of setae at base of forewing as in Figs 11 and 12; costal cell about $8 \times$ as long as broad; mid tibial spur long and slender, about $10 \times$ as long as broad; hind tibia slightly broadened and flattened, about $4.9 \times$ as long as broad; propodeum with a single, inconspicuous median carina in its posterior half. Relative measurements (holotype): FWL 264, FWW 102; HWL 180, HWW 46.

Gaster slightly shorter than the thorax; ovipositor hardly exerted at apex.

MALE. The males that we tentatively associate with the female are generally similar to female other than slightly darker coloration of legs, paler infuscation of forewings, relatively slightly narrower frontovertex and structure of antennae (Fig. 21) and genitalia (Fig. 106). Fore and mid coxae dark brown, hind coxae varying from yellow to dark brown; mid tibiae with apical two thirds mixed dark brown, especially proximally; hind tarsi dark brown; eyes separated from occipital margin by about one-third diameter of posterior ocellus; mandibles with two very short ventral teeth and a broad, minutely denticulate, dorsal truncation (Fig. 105). Relative measurements: (paratype 1): HW 95, FV 55; EL 43, EW 33, MS 29; SL 27, SW 10.5; (paratype 2) AL 28.5, MT 74.

VARIATION. There is some variation in the coloration of the hind coxae in the males as noted above. The male figured (Figs 20 and 21) has F1 significantly longer than in other males being about $1.5 \times$ as long as F6 and the stigmal vein curved whereas in the other males F1 is subequal to F6 and the stigmal vein is more or less straight (see also comments below).

HOSTS. Unknown.

DISTRIBUTION. Costa Rica.

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, Guanacaste P., Guanacaste NP, Cacao, 950m, 13.ii.1995 (J.S. Noyes) (BMNH). Paratypes: **Costa Rica**, 1♂, Puntarenas, Monteverde Reserve, 1550m, 16.viii.1986 (L. Masner); 1♂,

Puntarenas, Monteverde, St Luis Valley, 17.viii.1986 (L. Masner); 3♂, Guanacaste P., Guanacaste NP, Caño. 950–1200m, 13.ii.1995 (L. Masner). Holotype and paratypes in BMNH, paratypes in BMNH, INBio, CNC.

COMMENTS. Although the males differ slightly from the holotype female in having a relatively slightly narrower frontovertex, larger eyes and darker legs we are confident that they belong to the same species because the mandibles, venation, wing setation, infusate pattern on the forewings and general structure of the thorax and propodeum are virtually identical. The variation noted above in the relative lengths of F1 and F6 and shape of stigmal vein may suggest that a sixth Costa Rican species is represented in this material, but for the present we are accepting this as normal variation within the species.

C. sithon is a very distinctive species easily recognisable by the infusate pattern of the forewings.

Cercobelus ulixes sp. nov.

(Figs 13–16)

DIAGNOSIS. Female (length 2.65mm): antenna (Fig. 13) with funicle segments subequal and much longer than broad; mandibles with one short tooth and a very broad, slightly concave, smooth truncation; pronotum medially in dorsal view at least a little longer than mesoscutum; forewings (Fig. 14) conspicuously infusate from lineal calva to wing apex; marginal vein about four or five times as long as broad and touching anterior wing margin (Fig. 16); propodeum long medially, about two-thirds as long as scutellum; gaster very elongate, clearly longer than head and thorax combined; ovipositor distinctly exerted with exerted part nearly half as long as mid tibial spur. Male (length 1.84mm): very similar to female except for relatively longer and broader flagellar segments and shorter gaster.

FEMALE (HOLOTYPE). Body generally blackish with a weak brassy lustre on head and dorsum of thorax; scape dark brown, pedicel and flagellum brown; forewings (Fig. 14) infusate from lineal calva to apex with a pair of opposite, longitudinal hyaline streaks distad of venation, the lower one extending to lineal calva; all coxae blackish; fore femora dark brown in basal half or so, apex amber; foretibiae and tarsi amber; mid femur dark brown with basal one-third whitish; mid tibia with a narrow, dark brown basal ring, a white subbasal ring followed by a dark brown ring, distal half yellowish; mid tibial spur and tarsi yellow; hind femur dark brown proximally amber; hind tibia dark brown, slightly less than proximal one-third white; hind tarsus dark brown.

Head with fairly regular, raised reticulate sculpture

on frontovertex of mesh subequal to the diameter of an eye facet, sculpture becoming more elongate and less regular below top of antennal toruli; inner margins of eyes slightly sinuate; eyes inconspicuously hairy and separated from occipital margin by slightly less than the diameter of an ocellus; ocelli forming a strongly obtuse angle; occipital margin sharply carinate; proportions of antennae as in Fig 13. Relative measurements: HW 87; FV 46; POL 21; OOL 9; OCL 9; EL 50; EW 32; MS 24; SL 44; SW 7.

Mesoscutum with fairly regular raised, reticulate sculpture, similar to that on frontovertex, but perhaps a little shallower and finer; scutellum with similar, but more shallow sculpture, especially at apex which is almost smooth; mesoscutum about 2 × as broad as long and slightly shorter than pronotum medially in dorsal view; scutellum clothed in very conspicuous, long setae; venation and distribution of setae at base of forewing as in Figs 15 and 16; costal cell about 12 × as long as broad; mid tibia with a line of very conspicuous bristles along its length externally; mid tibial spur long and slender, about 8 × as long as broad; hind tibia slightly broadened and flattened, only a little over 6 × as long as broad. Relative measurements: FWL 305, FWW 109; HWL 225, HWW 48.

Gaster very slender and elongate, excluding the ovipositor about 3 × as long as broad and about as long as head and thorax together; cercal plates in apical one-third; ovipositor slightly exerted at apex, the exerted part nearly half as long as mid tibial spur.

MALE. Length 1.84mm. Generally very similar to female but frontovertex slightly wider, antenna with F1 nearly 2 × as long as pedicel and other flagellar segments relatively more elongate so that flagellum is about 1.4 × as long as width of head, clava solid and gaster about two-thirds as long as thorax. Setae on funicle not longer than width of segments.

HOSTS. Unknown.

DISTRIBUTION. Costa Rica.

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, Cartago, La Cangreja, 1950m, vii.1991 (P. Hanson, C. Godoy). Paratype, **Costa Rica**, 1♂, Heredia, Uvita de San Rafael, 1700m, 10.iii.1991 (P. Hanson). Material in BMNH.

COMMENTS. *Cercobelus ulixes* females can be separated from those of all other species of *Cercobelus* by the extremely elongate pronotum, propodeum and gaster. The male differs from other Costa Rican species in having setae on the flagellum which are not longer than the diameter of the segments.

Cercobelus godoyae sp. nov.

(Figs 17–19, 103 and 104)

DIAGNOSIS. Female (length 2.01–2.21 mm): antenna (Fig. 17) with F1 and F2 subequal and longer than broad; mandibles (Fig. 103) with three, short, obtuse teeth; mesoscutum about $2.5 \times$ as long as pronotum medially in dorsal view; forewings conspicuously infusate below apex of venation (Fig. 18); marginal vein punctiform, not quite touching anterior wing margin (Fig. 19); propodeum long medially, nearly one-third length of scutellum and with a pair of posteriorly diverging, median carinae; gaster elongate, about as long as thorax; ovipositor distinctly less than $0.5 \times$ as long as mid tibia. Male: unknown.

FEMALE (HOLOTYPE). Length 2.21 mm. Body generally blackish with a weak brassy lustre on head, green lustre on mesoscutum and purplish lustre on scutellum; antennae amber-testaceous; wings mostly hyaline but with a conspicuous triangular infusate area about half way across wing from stigmal vein (Fig. 18) extending as a narrow median streak towards wing apex; all coxae blackish; fore femora dark brown in basal half or so, apex amber; foretibiae and tarsi amber; mid and hind femora mostly dark brown but amber basally, the hind femora distinctly so; mid tibiae basally dark brown; apical half, and spur amber, tarsi amber; hind tibiae dark brown, almost black, tarsi dark brown. Head with fairly regular, raised reticulate sculpture on frontovertex, this becoming more elongate and less regular towards eyes and on lower parts of face and genae; inner margins of eyes slightly sinuate; eyes moderately hairy; ocelli forming a strongly obtuse angle; occipital margin sharply carinate; proportions of antennae as in Fig. 17, pedicel and flagellum together equal in length to head width. Relative measurements: HW 90; FV 54; POL 32; OOL 9; OCL 8; EL 46; EW 32; MS 28; SL 39; SW 7.5.

Mesoscutum with fairly regular raised, reticulate sculpture, slightly deeper than that on frontovertex, anteriorly tending to imbricate-reticulate; scutellum with similar, but more shallow sculpture, especially at apex which is almost smooth; mesoscutum about $1.5 \times$ as broad as long and about $2.5 \times$ as long as pronotum medially in dorsal view; venation and distribution of setae at base of forewing as in Figs 18 and 19; costal cell about $10 \times$ as long as broad; mid tibial spur long and slender, nearly $10 \times$ as long as broad; hind tibia slightly broadened and flattened, only a little over $4 \times$ as long as broad; propodeum with two, posteriorly diverging, median carinae. Relative measurements: FWL 253, FWW 98; HWL 150, HWW 50.

Gaster about as long as thorax; ovipositor (Fig. 104) slightly exserted at apex; last tergite clearly constricted level with apical gastral spiracle and broadening again subapically, its apex broadly truncate. Relative measurements (paratype): OL 24; GL 9 [MT 55].

MALE. Unknown.

HOSTS. Reared from *Katacephala* sp. nov. (D. Hollis, pers. comm.) (Psyllidae) on *Eugenia carthagensis* (Myrtaceae).

DISTRIBUTION. Costa Rica (Cartago).

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, Cartago, Tobasi, 1500m, ex *Katacephala* (D. Hollis, sp. nov. #2, pers. comm.) on Myrtaceae (*Eugenia carthagensis*, D. Hollis, pers. comm.), 6.iv.1993 (P. Hanson, D. Hollis). Paratypes: **Costa Rica**, 2♀, same data as holotype. Holotype and paratype in BMNH, paratype in INBio.

COMMENTS. *Cercobelus godoyae* can be separated from the other species of *Cercobelus* from Costa Rica by the characters given in the key (see also comments under *daphne*) and from the only other described species (*jugaesus* Walker from Europe) by the relative length of the funicle segments, forewing venation and the infusate forewing. *C. jugaesus* has F1 distinctly longer than F2 and the marginal vein of the forewing at least about twice as long as broad and the forewing not infusate or hardly so.

Cercobelus daphne sp. nov.

DIAGNOSIS. Female (length 2.79 mm): antenna with all funicle segments longer than broad; mandibles with a very short, obtuse lower tooth and a broad truncation; mesoscutum slightly more than twice as long as pronotum medially in dorsal view; forewings conspicuously infusate below apex of venation; marginal vein punctiform, not quite touching anterior wing margin; propodeum long medially, about one-third length of scutellum; gaster elongate, nearly as long as head and thorax together. Male: unknown.

FEMALE. Body generally blackish with a weak purple and bluish lustre on head and mesoscutum and blue, purple and brassy lustre on scutellum; antennae with scape yellow and flagellum brown; wings mostly hyaline but with a conspicuous triangular infusate area to about half way across wing from stigmal vein extending as an inconspicuous narrow median streak towards wing apex; all coxae blackish; fore femora dark brown in basal half or so, apex amber; foretibiae and tarsi amber; fore and mid legs mostly yellow, the mid tibia marked a small area of dark brown basally, hind femora basally yellow, remainder of leg dark brown; gaster dark brown with some purple and brassy reflections.

Head with fairly regular, raised reticulate sculpture on frontovertex, this becoming more elongate and less regular towards eyes and on lower parts of face and genae; inner margins of eyes slightly sinuate; eyes moderately hairy; ocelli forming a strongly obtuse angle; occipital margin sharply carinate; antenna with flagellum a little longer than head width with all

funicle segments clearly longer than broad, F1 longer than pedicel and nearly $2.5 \times$ as long as broad, F4 about $0.75 \times$ as long as F1 and about $1.5 \times$ as long as broad. Relative measurements: HW 104; FV 62; POL 35; OOL 11; OCL 9; EL 54; EW 38; MS 34; SL 51; SW 9.

Mesoscutum with fairly regular raised, reticulate sculpture, slightly deeper than that on frontovertex, anteriorly tending to imbricate-reticulate; scutellum with similar sculpture anteriorly, but more shallow sculpture towards apex which is almost smooth; mesoscutum about $1.7 \times$ as broad as long and about $2 \times$ as long as pronotum medially in dorsal view; venation and distribution of setae at base of forewing similar to that of *godoyae* (Fig. 18); costal cell about $10 \times$ as long as broad; mid tibial spur long and slender, nearly $10 \times$ as long as broad; hind tibia slightly broadened and flattened, nearly $5 \times$ as long as broad. Relative measurements: FWL 320, FWW c123; HWL 219, HWW 66.

Gaster nearly as long as head and thorax together; ovipositor slightly exerted at apex.

MALE. Unknown.

HOSTS. Unknown.

DISTRIBUTION. Costa Rica (Puntarenas).

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, Puntarenas, Monteverde, 25.v.1993 (Michalski). In BMNH.

COMMENTS. *Cercobelus daphne* is closest to *godoyae* and can be separated from this species by its larger size, the pedicel and flagellum together being longer than head width (equal in *godoyae*), relatively longer gaster, paler fore and mid legs and presence of only one median carina on propodeum (two in *godoyae*).

TRECHNITES Thomson

Trechmites Thomson, 1876: 118. Type species *Trechmites fuscitarsis* Thomson by monotypy.

Psylledontus Crawford, 1910: 88. Type species *Psylledontus insidiosus* Crawford, by original designation. Synonymy with *Trechmites* by Ferrière, 1961.

Metalonella Girault, 1915: 77. Type species *Metalonella australiensis* Girault, by original designation. Synonymy with *Psylledontus* by Peck, 1951 and with *Trechmites* by Ferrière, 1961.

DIAGNOSTIC CHARACTERS. Head and thorax generally metallic green; funicle 5-segmented; clava 3-segmented; mesoscutum with notaular lines present, but superficial and inconspicuous, occasionally absent; forewing with marginal vein punctiform, virtually absent; postmarginal vein virtually absent;

hypopygium reaching apex of gaster, frequently reaching past apex of last tergite and completely enclosing the ovipositor; ovipositor slightly to strongly modified with gonostyli varying from free to completely fused with the second valvifers. Male hardly differing from female, clava entire, pedicel sometimes enlarged; parameres not developed, digiti elongate, each with one or two apical teeth.

BIOLOGY. Parasitoids of psyllid nymphs. The described species have been recorded from *Caillardia* spp. and *Psylla* spp.

USE IN BIOCONTROL. One species, *T. psyllae* (Ruschka), was been imported into California (USA) from Switzerland for the control of *Psylla pyricola* Förster in 1965 (Clausen, 1978). No further information is available. The same species is accredited with effective control of *Psylla pyri* Linnaeus in the pear orchards of Georgia (Chkhaidze & Khlopunov, 1971).

DISTRIBUTION. Cosmopolitan.

IDENTIFICATION OF SPECIES. Of the 17 described species, five old world species are keyed by Hayat, *et al.* (1975), six Palaearctic species by Trjapitzin (1989) and four southern African species are reviewed by Prinsloo (1981).

COMMENTS. *Trechmites* is probably closest to *Cercobelus*, both genera including species parasitic on psyllids and having reduced antennal segmentation and similar modified ovipositor structure. The two genera can be separated from each other by a number of characters, but most notably the difference in number of funicle segments (see key), the complete lack of notaular lines in *Cercobelus*, and less modified gaster in *Trechmites* (strongly telescopic in *Cercobelus*).

Trechmites merops sp. nov.

(Figs. 22–25, 107–110)

DIAGNOSIS. Female (0.94–0.97mm): hind tarsi brown, contrasting with the yellow fore and mid tarsi; mesoscutum shining metallic green with notaular lines relatively conspicuous and meeting medially at the posterior margin of the mesoscutum; scutellum relatively dull with very fine punctate-reticulate sculpture which contrasts strongly with the shallower sculpture of the mesoscutum; last tergite with a pair of apical lateral invaginations; hypopygium with a median, apical extension which reaches past apex of last tergite and completely encloses the ovipositor. Male (0.87–0.90mm): similar to female but for genitalia and solid clava.

FEMALE (HOLOTYPE). Length 0.97mm. Head black with a strong metallic coppery or purple sheen mixed with green, scrobal area distinctly purple; scape black

with apex yellow; flagellum dark brown; pronotum purple-brown; mesoscutum bright metallic green, purplish towards posterior margin; axillae coppery-purple, dull; scutellum relatively dull but of silky appearance, medially coppery-purple, towards sides and apex metallic green; coxae and femora blackish, bases of femora pale yellow; tibiae blackish, apical one third of fore tibiae, mid tibial spur and slightly more than apical half of mid tibia pale yellow; fore and mid tarsi yellow, hind tarsi dark brown; wings hyaline; gaster blackish with a purple and green sheen.

Frontovertex with shallow, fairly regular reticulate sculpture of mesh a little larger than eye facet; sculpture in scrobal area irregular and longitudinally elongate; interantennal prominence with very shallow, regular, reticulate sculpture; scrobes wide and more or less touching eyes; ocelli forming an acute angle; eyes not conspicuously hairy; mandibles (Fig. 107) with two teeth and a broad truncation, the second tooth obtuse, very short and almost absent; proportions of antenna as in Fig. 22. Relative measurements: HW 64; FV 21; OOL 10; POL 2; OCL 3.5; EL 43; EW 32; MS 18; SL 30; SW 8.

Mesoscutum with notaular lines well marked and more or less meeting medially at posterior margin; mesoscutum with shallow, imbricate-reticulate sculpture, the mesh finer medially and near posterior margin; axillae and scutellum with conspicuously deeper and finer, punctate-reticulate sculpture, extreme apex quite smooth and polished; venation and setation at base of forewing as in Figs 23 and 24; propodeum outside spiracle with only one or two inconspicuous setae. Relative measurements: FWL 153, FWW 63; HWL 90, HWW 22.

Gaster about as long as thorax; hypopygium (Fig. 109) medially produced at apex, extending past apex of last tergite and completely enclosing the ovipositor; ovipositor (Fig. 108) with gonostyli partially fused to second valvifers. Relative measurements (paratype): OL 21.5; GL 7 [MT 28].

MALE. Generally almost identical to female but differing in antenna (Fig. 25) with clava solid and in the structure of the genitalia (Fig. 110).

HOSTS. Reared from *Trioza* sp. nov. (D. Hollis, pers. comm.) (Triozidae) on *Clethra* sp. (Clethraceae).

DISTRIBUTION. Costa Rica (700–1700m).

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, Heredia, San Rafael, Uvita, 1700m, ex psyllid on *Clethra*, iii.1992 (P. Hanson). Paratypes: **Costa Rica**, 1♂, Puntarenas, Monteverde, 15.xii.1985–5.i.1986 (A. Forsyth); 1♂, Puntarenas, Monteverde, Finca Canada, 1500–1600m, 23–27.ii.1991 (B.J. Sinclair); 1♂, Guanacaste, Guanacaste NP, 9Km S. Santa Cecilia, Est. Pitilla, 700m, vi.1989

(I.D. Gauld). Holotype and paratypes in BMNH.

COMMENTS. *T. merops* can be separated from other species of the genus by the relatively dull scutellum which has very finely punctate-reticulate sculpture which is clearly much deeper than the more coarse reticulate sculpture of the mesoscutum. In other species the scutellum is generally at least as shiny as the mesoscutum and the sculpture is relatively shallow and rather elongate, almost striate. There are also notable differences in the shape of the apex of the last tergite and hypopygium, many species having the apical part of the last tergite much more highly modified than in *merops* and the hypopygium less strongly extended posteriorly.

HOMALOTYLUS Mayr

Homalotylus Mayr, 1876: 752. Type species *Encyrtus flaminus* Dalman, by subsequent designation of Ashmead, 1900.

Nobrimus Thomson, 1876: 116. Type species *Encyrtus flaminus* Dalman, by subsequent designation of Timberlake, 1919. Synonymy with *Homalotylus* by Timberlake, 1919.

Mendozaniella Brèthes, 1913: 97. Type species *Mendozaniella mirabilis* Brèthes, by monotypy. Synonymy with *Homalotylus* by Timberlake, 1919.

Hemaenasoidea Girault, 1916: 307. Type species *Hemaenasoidea oculata* Girault, by monotypy. Synonymy with *Homalotylus* by Timberlake, 1919.

Anisotylus Timberlake, 1919: 170. Type species *Homalotylus similis* Ashmead, by original designation. Synonymy with *Homalotylus* by Noyes & Hayat, 1984.

Lepidaphycus Blanchard, 1936: 13. Type species *Lepidaphycus bosqi* Blanchard, by monotypy. Synonymy with *Homalotylus* by Blanchard, 1941.

Neoaenasioidea Agarwal, 1966: 71. Type species *Neoaenasioidea indica* Agarwal, by original designation. Synonymy with *Homalotylus* by Hayat, Alam & Agarwal, 1975.

DIAGNOSTIC CHARACTERS. Length about 1.5–2mm; males and females extremely similar and often difficult to separate; head (Fig. 111) about as long as broad or longer; eyes more or less kidney-shaped and at least about 3 × as long as malar space; mandible tridentate (Fig. 112); antenna (Fig. 26) with scape subcylindrical, at least about 6 × as long as broad; funicle 6-segmented with segments subequal in width and subquadrate or conspicuously longer than broad; clava unsegmented or with partial segmentation, with a conspicuous, oblique apical truncation; mesoscutum with notaular lines complete and more or less meeting at posterior margin of mesoscutum; forewings (Fig. 27) partly infusate and with stigmal vein generally

abruptly bent immediately below marginal vein (Fig. 28); hypopygium reaching apex of gaster; last tergite short so that cercal plates are in apical one-third of gaster; ovipositor (Fig. 113) frequently well exerted.

BIOLOGY. Gregarious endoparasitoids of coccinellid larvae (Coleoptera, Coccinellidae) feeding on sternorrhynch homopterans (Coccoidea, Aphidoidea and Psylloidea). Nothing has been published on the immature stages. The adult parasitoids emerge from the prepupal stage of the hosts. There are one or two records of individuals having been reared from the larvae of Chrysomelidae and Bruchidae but these require confirmation. Records of species of the genus being parasitoids of scale insects (Homoptera, Coccoidea) are almost certainly incorrect, the true host probably being coccinellid larvae feeding on the scale insects.

DISTRIBUTION. Cosmopolitan.

IDENTIFICATION OF SPECIES. The most comprehensive work revising species of the genus is that of Timberlake (1919). A number of species have been described more recently, mostly from the Old World, and therefore the following works may be of use: Trjapitzin (1989; Palaearctic); Noyes & Hayat (1984; Indo-Pacific).

COMMENTS. *Homalotylus* is included here because one species (*hyperaspidis* Timberlake) has been reared from larvae of *Hyperaspis* sp. feeding on trioizids, or coccids inside the leaf gall produced by *Trioza* sp. nr *maritima* on *Avicennia germinans* (Guanacaste Prov., Guanacaste NP, Playa Naranja, 11.iii.1990, J.S. Noyes, J. Cox). This species will be dealt with elsewhere.

CALDENCYRTUS gen. nov.

Type species: *Caldencyrtus mitchelli* sp. nov. Gender masculine.

DIAGNOSTIC CHARACTERS. About 2–2.5 mm in length; body generally blackish with a metallic green lustre; mandibles with two teeth and a truncation; occipital margin sharp, carinate; mouth opening at least about as wide as frontovertex (Fig. 114); wings hyaline to slightly infuscate; forewing venation with marginal vein three or four times as long as broad and subequal in length to stigmal and postmarginal veins, the stigmal vein forming an angle of about 45° with anterior wing margin (Fig. 31); mesopleuron expanded posteriorly and more or less touching base of gaster and thus propodeum not clearly visible between it and base of gaster in side view. Female: antennal toruli at level with lowest eye margins (Fig. 114); scape subcylindrical; funicle 6-segmented; clava 3-segmented; gaster with hypopygium generally reaching

about half way along gaster; ovipositor distinctly exerted. Male: antennal toruli about level with lowest eye margins; funicle 6-segmented, clothed in short setae; clava 2-segmented (Fig. 32); phallobase with parameres developed but short and inconspicuous, digiti moderately long and each with an apical hook.

FEMALE. Head in facial view about $1.2 \times$ as broad as long, in profile about $2 \times$ as long as deep and anteriorly more or less gradually and evenly curved, but most strongly so at level with top of antennal scrobes. Eye with posterior margin more or less straight, about $1.5 \times$ as long as broad, slightly longer than width of frontovertex, reaching or nearly reaching occipital margin which is sharply carinate at least medially. Malar space about $2/3$ as long as an eye and with sulcus absent or indicated by a slight change in sculpture. Frontovertex about $2/5$ head width; ocelli forming an angle of about 90°, posterior ones much closer to eyes than to occipital margin. Antennal scrobes very shallow and hardly meeting dorsally, not reaching half way from toruli to anterior ocellus; antennal toruli separated from mouth margin by slightly more than their own lengths and from each other by nearly the same distance, their upper most margins about level with, or a little above lowest eye margins; clypeal margin with a truncate median lobe (Fig. 114); mouth opening about as wide as frontovertex or wider. Antennal scape subcylindrical to slightly flattened; about $3 \times$ as long as broad and not longer than minimum frontovertex width; pedicel conical, about $1/3$ as long as scape and subequal in length to any funicle segment which are subquadrate or distinctly longer than broad; clava apically rounded, 3-segmented and about $1/3$ as long as funicle; longitudinal sensilla on all flagellar segments; longest setae about half as long as width of corresponding segment. Frontovertex with shallow piliferous punctures, weakly metallic, the sculpture moderate and more or less transversely elongate; setae on frontovertex inconspicuous and each shorter than diameter of anterior ocellus; eye apparently naked, but with sparse extremely short setae. Mandibles with two teeth and a truncation (Fig. 115); maxillary palpi 4-segmented, labial palpi 3-segmented.

Thorax in side view moderately robust with mesoscutum and scutellum moderately convex; mesopleuron slightly enlarged posteriorly and nearly touching base of gaster so that propodeum appears to be well-separated from hind coxae. In dorsal view the posterior margin of pronotum moderately concave; visible part of mesoscutum slightly less than twice as broad as long, with notaular lines absent, its posterior margin slightly to moderately produced; axillae meeting medially or nearly so; scutellum with apex rounded, about as long as broad; propodeum medially about $1/7$ as long as scutellum and with some shallow, irregular sculpture and with a conspicuous group of silvery

setae lateral to each spiracle. Dorsum of thorax clothed with dark brown setae and with a slight metallic sheen, especially so on the scutellum; mesoscutum with polygonal, raised, reticulate sculpture of fairly fine mesh; scutellum with similar, but conspicuously deeper reticulate sculpture. Forewings hyaline to slightly infumate distally, about $2.5 \times$ as long as broad; linea calva entire and open; filum spinosum present; submarginal vein with a subapical hyaline break, parastigma hardly widened; costal cell about $11 \times$ as long as broad with 1 line of setae dorsally in its distal half; marginal vein about $3 \times$ as long as broad and subequal in length to both postmarginal and stigmal veins. Hindwing about $2/3$ as long as forewing and a little more than $3 \times$ as long as broad, marginal fringe a little less than $1/5$ wing width. Mid tibial spur slightly longer than adjacent basitarsus.

Gaster about as long as thorax; cercal plates in basal half; hypopygium medially reaching about one-third along gaster; paratergites absent; last tergite about as long as mid tibia or shorter; ovipositor slightly exerted, the exerted part shorter than mid tibial spur; ovipositor about as long as mid tibia or longer; gonostyli free, about one-quarter as long as ovipositor.

MALE. Very similar to female except for antenna and genitalia. Antenna separated from mouth margin by nearly twice the length of a torulus and with funicle segments slightly broadened, but longer than broad, clothed in relatively short setae, the longest about half as long diameter of a segment; clava 2-segmented (Fig. 32); aedeagus a little less than half as long as mid tibia; phallobase with parameres developed but short and inconspicuous, digiti moderately long and each with at least one apical hook.

COMMENTS. Initially we recognised only a single somewhat variable species in the genus, but further work has revealed that the available material includes three discrete morphological groups which differ consistently from one another in a number of characters. We are describing each group as a new species, even though all three were reared from trioqid galls (*Trioxys* spp. *magnoliae* group) on the leaves and fruit of *Cinnamomum hammelianum* collected in the same locality, Volcan Poas. It is not unknown for several species of the same parasitoid genus to be reared from a single host species or species complex in the same locality. For instance *Diglyphus minoens*, *D. isaea* and *D. poppoea* were all reared in the same month from *Chromatomyia syngesiae* on *Sonchus oleraceus* collected within a 100 metres of each other in Wimbledon, England (J. LaSalle, pers. comm.; material in BMNH). Other similar examples include several species of *Encarsia* emerging from the same whitefly host in the same area (J.B. Woolley, A. Polaszek, pers. comm.), *Aphytis* from diaspidid scales (J.B. Woolley, D. Rosen, pers. comm.), *Syrphophagus* as hyperparasitoids of

psyllids (J. Noyes, unpubl.; material in BMNH), more than one species of each of *Aphidius*, *Trioxys*, *Aphelinus*, *Asaphes* or *Pachyneuron* from the same aphid host in the same locality (R. Zuparko, pers. comm.). In addition we are able to recognise three distinct group of males. In an attempt to associate these males with their female counterparts we have assumed that both sexes show a similar state for certain characters. For instance, we have associated males with relatively small eyes with females having relatively small eyes and similarly males with slender antennae with females having relatively slender antennae.

The broad mandibles, differentiated marginal setae of the linea calva, lack of paratergites, short hypopygium and ovipositor structure place *Caldencyrtus* within the subfamily Encyrtinae. The mandibular structure, sharply carinate occipital margin, forewing venation (marginal, stigmal and postmarginal veins subequal in length and stigmal vein at an angle of about 45° to anterior wing margin), female abdominal structure and male genitalia suggest a close relationship with *Syrphophagus*. This relationship is also suggested by similar hosts, some species of *Syrphophagus* being associated with Psylloidea, although as hyperparasitoids. On the other hand, the species here included in *Caldencyrtus* display several characters which separate them from *Syrphophagus*. Most notably these are the strong posterior expansion of the mesopleuron, high placement of the antennal toruli in the female, wide mouth margin, and 2-segmented clava in the male. In *Syrphophagus* the mesopleuron is clearly separated from the base of the gaster by the propodeum laterally, the antennal toruli are below the lower eye margin and quite close to the mouth margin, the mouth is not conspicuously widened and the male clava is entire.

The species included in this new genus are tantalisingly very similar in general appearance to *Ginsiana vectius* (Walker) from Florida (USA), which is probably incorrectly placed in *Ginsiana*. The similarity suggests that *vectius* may be better placed in *Caldencyrtus*. The host of *vectius* is *Trioxys magnoliae* (Ashmead) and thus closely related to the hosts of the three species described below as new. However, we are unable to include *vectius* in the same genus at present because of apparently significant differences in the structure of the head, forewings and gaster. In *vectius* the mandibles have three subequal teeth, although the upper tooth is somewhat flattened and rounded, the frontovertex is not wider than one-third head width, the antennal toruli are separated from the mouth margin by less than their own lengths, the male antenna has a solid clava (although there is the merest hint of a division), and the female hypopygium reaches the apex of the gaster.

In the most comprehensive key to Neotropical

encyrtid genera available (Noyes, 1980), females of *Caldencyrtus* will run to either couplet 115 (*Parecthrodryinus*, = *Mahencyrtus*), couplet 120 or couplet 121 (*Hemencyrtus* and *Rhytidothorax*). Although probably not closely related to any of these genera, *Caldencyrtus* can be separated from *Mahencyrtus* by its lack of the subapical swelling (triangular expansion) of the submarginal vein, from *Hemencyrtus* by the hypopygium not reaching the apex of the gaster and from *Rhytidothorax* by the ovipositor being clearly visible externally and the mandibles being broad and with two teeth and a truncation, almost tridentate. In *Mahencyrtus* the submarginal vein has a distinct subapical swelling, in *Hemencyrtus* the hypopygium reaches the apex of the gaster and in Neotropical *Rhytidothorax* the ovipositor is externally hidden and the mandibles are very narrow with only one or two apical teeth. In the key to males *Caldencyrtus* will run to couplet 84 (*Trichomasthus* and *Syrphophagus*), but differs from both genera in having a two segmented clava, whilst the males of both these named genera have an entire clava.

Key to Costa Rican species of *Caldencyrtus*

- 1 Clava 3-segmented (females) 2
- Clava 2-segmented (males) 4

FEMALES

- 2 F1 about twice as long as broad, F6 at least about one-third longer than broad; last tergite elongate, at least nearly as long as mid tibia *antander* (p. 118)
- F1 not more than 1.5 × as long as broad, F6 quadrate or transverse; last tergite not more than 0.75 × as long as mid tibia 3
- 3 Eyes separated from occipital margin by a distance about equal to the diameter of two facets; foretibia largely dark brown, hind tibia almost entirely so *mitchelli* (p. 116)
- Eyes almost touching occipital margin; foretibia almost entirely amber-yellow, hind tibia with its apical half amber-yellow *acamas* (p. 117)

MALES

- 4 F1 with not more than about 10 longitudinal sensilla, F1 at least about 2.5 × as long as broad and a little narrower than pedicel *antander* (p. 118)
- F1 with at least 20 longitudinal sensilla, F1 not more than 2 × as long as broad and at least as wide as pedicel 5
- 5 Eyes nearly reaching occipital margin, separated by not more than the diameter of a facet; F1 with not more than 25 longitudinal sensilla, each relatively long, longer than one-quarter length of segment ... *acamas* (p. 117)

- Eyes separated from occipital margin by a distance at least equal to twice the diameter of a facet; F1 with at least 30 longitudinal sensilla, each not longer than one-fifth length of segment *mitchelli* (p. 116)

Caldencyrtus mitchelli sp. nov.

(Figs. 29–32, 114–119)

DIAGNOSIS. Female (length, excluding ovipositor: 1.78–2.07mm): fore tibia blackish in basal half, hind tibia almost entirely blackish; eyes clearly separated from occipital margin which is rounded at nearest point to eye; antenna (Fig. 29) with pedicel about 1.7 × as long as broad, F1 subequal in length and width to pedicel and about 1.4 × as long as broad; F6 quadrate or transverse; flagellum slightly shorter than head width; gaster slightly shorter than thorax, last tergite about three-fifths as long as mid tibia; hypopygium (Fig. 116) with posterior margin not strongly incised, the incised part less than one-third as long as mid tibial spur; ovipositor about as long as mid tibia. Male (length 1.59–2.00mm.): F1 at most about 2 × as long as broad and as wide as pedicel and with at least 30 longitudinal sensilla, each of which is not more than one-fifth as long as segment (Fig. 119); aedeagus (Fig. 118) with pores very close to its apex which is hardly acute; setae on each side of phallobase relatively far apart.

FEMALE (HOLOTYPE). Length 2.07mm. Head black with a faint purple and brassy sheen on face and on genae; scape and pedicel black, each with apex brown; flagellum dark brown; pronotum and mesoscutum black, mesoscutum distinctly, but weakly, metallic blue; scutellum dark coppery purple medially in basal half, remainder metallic blue-green with some purple reflections laterally; axillae black; tegulae dark brown, almost black; sides of pronotum and prepectus black; mesopleuron similar to prepectus but faintly brassy; sides of propodeum metallic green, slightly brassy; coxae blackish; femora concolorous but with apices of fore and mid femora amber, hind femora black; fore and hind tibiae black with extreme distal apex amber; mid tibiae black in basal half, apex dusky yellowish; tarsi brownish, mid tarsi with basitarsus ventrally yellow; wings almost hyaline, but distal half very faintly infuscate; gaster blackish with a metallic purple and green sheen, basal tergite more distinctly metallic green; visible part of gonostyli dark brown.

Frontovertex with scattered, shallow, inconspicuous piliferous punctures, mostly separated by more than their own diameters; sculpture in ocellar area moderately regularly reticulate, anterior to this of larger mesh, more irregular and transversely elongate; interantennal prominence with slightly shallower, reticulate sculpture, that on genae more irregular and

longitudinally elongate; scrobes smooth; posterior ocelli much nearer eyes than to the sharply carinate occipital margin; eyes separated from occipital margin by very nearly twice the diameter of a facet; antennal toruli with their mid-line slightly below lowest eye margins and separated from mouth margin by more than their own lengths (Fig. 114); mouth relatively wide, about half head width; mandibles (Fig. 115) with two teeth and a truncation; flagellum slightly shorter than head width, all segments longer than broad except F6 which is quadrate or transverse; other proportions of antenna as in Fig. 29. Relative measurements (holotype): HW 112; FV 49; POL 25.5; OOL 6; EL 58; EW 43; MS 40; SL 39; SW 11.5.

Mesoscutum with fairly regular, reticulate sculpture similar to that of frontovertex, tending to imbricate-reticulate anteriorly and on sides; sculpture on scutellum relatively deep and reticulate, even towards apex and sides, conspicuously deeper than that on mesoscutum, extreme sides and apex with shallow sculpture; axillae with sculpture similar to mesoscutum, but shallower, almost smooth; visible part of metapleuron naked, sides of propodeum clothed in conspicuous, silvery setae; setation on base of forewing and venation as in Figs 30 and 31. Relative measurements: FWL 330, FWW 138; HWL 218, HWW 64.

Gaster slightly inflated in critical point dried holotype, but about as long as thorax with ovipositor not exerted; gonostyli (Fig. 117) slightly shorter than mid tibial spur; last tergite about three-fifths as long as mid tibia; hypopygium (Fig. 116) reaching to about half way along gaster its posterior margin hardly incised medially, the incision less than one-third as long as mid tibial spur. Relative measurements (paratype): OL 80; GL 18; HI 6 [MT 74; MTS 22].

MALE. Generally similar to female but for slightly smaller eyes, higher placement of antennae, structure of antennae (Fig. 32) and genitalia (Fig. 118). Antennae with F1 at most about 2 × as long as broad and as wide as pedicel; longitudinal sensilla relatively small and numerous, F1 with at least about 30 and each not longer than one-fifth the length of the segment (Fig. 119); eyes separated from occipital margin by at least twice the diameter of a facet; aedeagus relatively broad with pores close to apex which is moderately acute (Fig. 118) and setae on each side of phallobase well separated. Relative measurements: HW 101, FV 48, POL 25, OOL 6, EL 46, EW 36, MS 37, SL 30, SW 12.

VARIATION. Very little in material available. In the male, the relative lengths of the funicle segments vary slightly, F1 varying from about 1.6 to 2 × as long as broad.

HOSTS. Reared from galls formed by *Trioza* sp. *mag-noliae* group on the leaves and fruit of *Cinnamomum hammelianum* (see below as *cinnamomifolia*

misidentification).

DISTRIBUTION. Costa Rica, higher altitudes.

MATERIAL EXAMINED.

Holotype♀, **Costa Rica**, Alajuela, Volcan Poas, 2400m, ex trioqid gall on fruit of *Phoebe cinnamomifolia*, 11.ii.1995 (P. Hanson). Paratypes: **Costa Rica**, ♀, Alajuela, Volcan Poas, 2500m, ex psyllid gall on Lauraceae, 26.v.1991 (P. Hanson); 1♂, Alajuela, P.N. Volcan Poas, 2500m, Lauraceae psyllid leaf gall, 22.ix.1991 (P. Hanson); 1♀, 1♂, Alajuela, Volcan Poas, 2400m, 4.iii.1994 (P. Hanson, C. Godoy); 2♂, Alajuela Volcan Poas, psyllid leaf gall *Cinnamomum cinnamomifolia*, 4.iii.1994 (P. Hanson, C. Godoy); 2♀, 2♂, same data as holotype; 1♂ Cartago, La Cangreja, 1950m, 9°48'W 83°58'W, vi–vii.1992 (P. Hanson). Holotype and paratypes in BMNH, paratype in INBio.

COMMENTS. *C. mitchelli* is generally similar to *acamas* and *antander* but the females can be separated by the relative lengths of the pedicel and funicle segments, distance between the eye and occipital margin, coloration of legs, relative lengths of last tergite and ovipositor and the shape of the hypopygium. The males can be separated by the size and number of longitudinal sensilla on the funicle, position of the setae on the phallobase and shape of the apex of the aedeagus (see key and relevant diagnoses).

Caldencyrtus acamas sp. nov.

(Figs. 33, 120–123)

DIAGNOSIS. Differs from *mitchelli* and *antander* as follows.

FEMALE. (length, excluding ovipositor 2.04–2.30mm, holotype 2.30mm). Foretibiae almost completely amber-yellow, mid and hind tibiae amber-yellow in apical half. Pedicel (Fig. 33) slightly more than 2 × as long as broad; F1 about 1.5 × as long as broad; eyes more or less reaching occipital margin which is sharply carinate to top of temples; ovipositor slightly exerted, exerted part nearly half as long as mid tibial spur; last tergite about 3/4 as long as mid tibia and with apex moderately acute; median incision in hypopygium about half as long as mid tibial spur (Fig. 123); ovipositor (Fig. 122) about one-quarter longer than mid tibia. Relative measurements (HOLOTYPE): HW 118; FV 48; POL 24; OOL 6; EL 64; EW 48; MS 40; SL 45; SW 12.5. FWL 370; FWW 140; HWL 250; HWW 58; (paratype): OL 95; GL 23; HI 12 [mid tibia 72, mid tibial spur 23].

MALE. (length 1.84mm). Foretibiae slightly infusate in basal half; antenna with F1 at most about 2 × as long as broad and as wide as pedicel; longitudinal sensilla

relatively numerous and short, F1 with at most 25 and each longer than one-quarter length of segment (Fig. 121); setae on each side of phallobase relatively close together; aedeagus (Fig. 120) with pores relatively well separated from its apex which is fairly acute.

VARIATION. Very little in material available.

HOSTS. Reared from galls formed by *Trioza* sp. *magnoliae* group on the fruit of *Cinnamomum hammelianum* (see below as *cinnamomifolia* misidentification).

DISTRIBUTION. Costa Rica, higher altitudes.

MATERIAL EXAMINED.

Holotype ♀: **Costa Rica**, Alajuela, P.N. Volcan Poas, 2500m, Lauraceae psyllid fruit gall, 22.ix.1991 (P. Hanson). Paratypes: **Costa Rica**, 1♀, same data as holotype; 3♂, Volcan Poas, ex trioqid fruit gall on *Phoebe cinnamomifolia*, i/ii.1995 (P. Hanson). Material in BMNH.

COMMENTS. *P. acamas* is close to *mitchelli* and *antander* and can be separated using the characters given in the key (see also relevant diagnoses and comments under *mitchelli*).

***Caldencyrtus antander* sp. nov.**

(Figs. 34, 124–127)

DIAGNOSIS. Differs from *mitchelli* and *acamas* as follows.

FEMALE. (length, excluding ovipositor 2.15–2.54mm, holotype 2.15mm). Foretibiae dark brown in basal half, mid and hind tibiae amber-yellow in apical half. Pedicel (Fig. 34) slightly more than 2 × as long as broad; F1 about 2 × as long as broad; eyes not quite reaching occipital margin which is sharply carinate at nearest point; ovipositor (Fig. 127) slightly exerted, exerted part about half as long as mid tibial spur; last tergite about as long as mid tibia and with apex strongly acute; median incision in hypopygium (Fig. 126) at least two-thirds as long as mid tibial spur; ovipositor more than 1.5 × as long as mid tibia. Relative measurements (HOLOTYPE): HW 104; FV 43; POL 22; OOL 4.5; EL 54; EW 38; MS 38; SL 39; SW 11. FWL 330; FWW 130; HWL 208; HWW 55; (paratype): OL 134; GL 34; HI 21.5 [MT 82, MTS 27].

MALE. (length 1.78–1.96mm). Foretibiae dark brown in basal two-thirds; F1 at least 2.5 × as long as broad and slightly narrower than the pedicel; antenna with relatively few longitudinal sensilla, F1 only with about 10 and each a little longer than one-fifth length of segment (Fig. 124); setae on each side of phallobase relatively well separated; aedeagus with pores well separated from its apex which is acute (Fig. 125).

VARIATION. Very little in material available.

HOSTS. Reared from galls formed by *Trioza* sp. *magnoliae* group on leaves of *Cinnamomum hammelianum* (see below as *cinnamomifolia* misidentification).

DISTRIBUTION. Costa Rica, higher altitudes.

MATERIAL EXAMINED.

Holotype♀: **Costa Rica**: Alajuela, Volcan Poas, 2400m, *Cinnamomum cinnamomifolia* leaf gall, *Trioza* sp. *magnoliae* group (as ?*Trioza anceps*), 4.iii.1994 (P. Hanson, C. Godoy). Paratypes: **Costa Rica**, 1♀, Alajuela, P.N. Volcan Poas, ex psyllid gall on Lauraceae, 2500m, 25.x.1990 (P. Hanson); 1♂, Alajuela, Volcan Poas, ex trioqid gall on leaf of *Phoebe cinnamomifolia*, i/ii.1995 (P. Hanson); 1♀, Cartago, La Cangreja, 1950m, vii.1991 (P. Hanson, C. Godoy); 1♀, Cartago, La Cangreja, 1950m, vi.1991 (P. Hanson); 1♀, Cartago, La Cangreja, 9°48'N 83°58'W, 1950m, vi.vii.1992 (P. Hanson). Material in BMNH.

COMMENTS. *C. antander* is similar to *mitchelli* and *acamas* and can be separated using the characters given in the key (see also relevant diagnoses and comments under *mitchelli*).

METAPHYCUS Mercet

Aenasioidea Girault, 1911: 171. Type species *Aenasioidea latiscapus* Girault, by original designation and monotypy. Synonymy with *Metaphycus* by Noyes & Woolley, 1994.

Metaphycus Mercet, 1917: 138. Type species *Aphycus zebratus* Mercet, by monotypy, as subgenus of *Aphycus* Mayr.

Tyndarichoides Girault, 1920: 189. Type species *Tyndarichoides mexicanus* Girault, by monotypy. Synonymy with *Metaphycus* by Noyes & Woolley, 1994.

Mercetiella Dozier, 1926: 98. Type species *Mercetiella reticulata* Dozier, by original designation. Synonymy with *Metaphycus* by Noyes, 1980.

Oaphycus Girault, 1932: 5. Type species *Aphycus sanguinithorax* Girault, by original designation. Synonymy with *Metaphycus* Noyes & Hayat, 1984.

Erythrphycus Compere, 1947: 7. Type species *Erythrphycus argyrocomus* Compere, by original designation. Synonymy with *Metaphycus* by Noyes & Woolley, 1994.

Melanaphycus Compere, 1947: 5. Type species *Pseudococcobius fumipennis* Timberlake, by original designation. Synonymy with *Metaphycus* by Noyes 1980.

Anaphycus Sugonjaev, 1960: 372. Type species *Aphycus nitens* Kurdjumov, by original designation. Synonymy with *Metaphycus* by Trjapitzin, 1971.

Notoencyrtus De Santis, 1964: 211. Type species *Notoencyrtus guttofasciatus* De Santis, by original designation. Synonymy with *Metaphycus* by Noyes, 1980.

DIAGNOSTIC CHARACTERS. Female: body generally matt yellow, orange or brown, only a few slightly metallic species known; scape frequently broadened and flattened; funicle 6-segmented, segments usually transverse or quadrate, rarely longer than broad; clava 3-segmented; mandibles tridentate; mesoscutum entire or with conspicuous complete or incomplete notaular lines; forewing with marginal vein more or less punctiform, postmarginal present, but generally rather short; with the exception of the species described below, the linea clava is interrupted by at least one or two lines of setae near posterior margin of forewing, sometimes completely closed at this point; forewings varying from hyaline to conspicuously infusate; gaster generally short with hypopygium usually not reaching more than about two-thirds along gaster; ovipositor rarely conspicuously exerted. Male: generally similar to female but mostly conspicuously darker, frequently dark brown if female is yellow or orange; a few species so similar to female that sexing is difficult; antenna varying from similar to female to all segments being longer than broad and clothed in relatively long setae, but these not longer than diameter of segments.

BIOLOGY. Almost always parasitic on various families of Coccoidea (mainly Coccidae, Eriococcidae, Diaspididae, Asterolecaniidae and Kermesidae) one Nearctic species has been recorded as parasitic on triozids. Some species have been reared from whitefly nymphs in Brazil (undetermined species, ex *Aleurothrixus floccosus*), Venezuela (undetermined species, ex *Bemisia tabaci*) and USA, Florida (*Metaphycus angustifrons*, ex *Aleurothrixus floccosus*) (material in BMNH). In Costa Rica, two species, both described below as new have been reared from triozid galls. A further undescribed species has been collected in association with *Trioza* sp. forming leaf galls on *Avicennia germinans* in Guanacaste Province. This latter species is not dealt with here because it was not reared and may be a parasitoid of soft scales (Coccidae) on the same plant.

The biology and immature stages of several species of *Metaphycus* have been described by numerous authors (Alam, 1957, 1958; Blumberg, 1982, 1988; Blumberg & DeBach, 1981; Blumberg & Swirski, 1982, 1984; Blumberg, *et al.* 1993; Chumakova, 1961; Flanders, 1942, 1952; Ibrahim, 1988; Ibrahim & Copland, 1987; Macropodi, 1985; Maple, 1947; Monaco, 1976; Podsiadlo, 1986 1991; Smith & Compere, 1928; Viggiani & Guerrieri, 1988). A summary of these papers will be included as part of a revision of the Costa Rican species of the genus.

USE IN BIOCONTROL. About 30 species have been used in various parts of the world for the biological control of about 20 pest species of soft scales (Coccidae) and armoured scales (Diaspididae). Many of these have proven successful with the best known being *M. helvolus*, which is successfully used for the control of *Saissetia oleae* in California. DeBach (1974) suggests the introduction of this species into the Fillmore district of California saved approximately \$300,000 US per year for the period 1960–1970. This species is now being used as a successful agent for the biocontrol of various soft scales in greenhouses in Europe (Viggiani, 1978; Noyes & Hayat, 1994).

DISTRIBUTION. Cosmopolitan.

IDENTIFICATION OF SPECIES. This is a large genus containing about 200 described species, the identification of which is usually difficult and almost always requires the examination of good quality slide-mounted material. The following papers provide keys to some of the species and may be of use: Timberlake (1916) for mainly North American species (as *Aphycus*), Trjapitzin (1975, 1989) for Palaearctic species, Annecke & Mynhardt (1971, 1972, 1981) for Afro-tropical species, and Shafee *et al.* (1975) for some Indian species. The Indo-Pacific species are reviewed by Noyes & Hayat (1984).

COMMENTS. Although *Aenasioidea* has priority over *Metaphycus* we are retaining the much more well known name *Metaphycus* as the valid name pending the results of an application to the International Commission of Zoological Nomenclature for the suppression of *Aenasioidea* in favour of *Metaphycus*.

Key to Costa Rican species of *Metaphycus* associated with psyllid galls

- 1 Head, thorax and gaster completely dark brown and slightly shiny *gallicola* (p. 119)
- Head dorsum of thorax mostly orange, sides of thorax and gaster whitish *electra* (p. 120)

***Metaphycus gallicola* sp. nov.**

(Figs 35–37, 128–129)

DIAGNOSIS. Female (length 1.00–1.14mm): head and dorsum of thorax almost completely black, slightly shiny, but not metallic; face with a narrow, transverse whitish line from malar sulci across top of antennal scrobes; scape dark brown; F1–F4 brown, F5–F6 yellow, clava with proximal segment brown, remainder yellow; fore and mid legs mostly dark brown, tarsi yellow; mid legs with tarsi and most of tibiae yellow; wings hyaline; gaster dark brown; scape slightly broadened and flattened, less than 3 × as long as broad; frontovertex about one-third head width; ocelli in an

equilateral triangle; notaular lines absent; hypopygium nearly reaching apex of gaster; ovipositor hidden. Male (length 0.88–0.92mm): very similar to female except for flagellum entirely testaceous-brown, solid clava and genitalia structure.

FEMALE (HOLOTYPE). Length 1.14mm. Head black and slightly shiny; face with a transverse v-shaped white line across top of scrobes and almost reaching each malar sulcus; scape (Fig. 35) almost completely blackish brown, extreme apex slightly yellowish; pedicel dorsally dark brown, ventrally and apically paler, testaceous; F1–F3 dark brown; F4 dark brown, ventrally paler; F5–F6 yellow; basal segment of clava brown, apical segments yellow; thorax dark brown; all coxae dark brown; femora dark brown, with basal one-third of mid femora pale yellow; fore tibiae mostly dark brown with extreme base and apical one-third yellow; mid tibiae yellow with an indistinct, narrow subbasal brown band; hind tibiae dark brown with extreme apices yellow; tarsi yellow, pretarsi dark brown; wings hyaline, venation testaceous brown; gaster dark brown.

Head with regular, fine, reticulate sculpture of mesh slightly smaller than an eye facet; sculpture fine, but more irregular on lower parts of face; ocelli forming an angle of slightly more than 60°; eyes clothed in moderately conspicuous short setae, each about as long as diameter of a facet; proportions of antennae as in Fig. 35; only F6 and clava with longitudinal sensilla; maxillary palpi 3-segmented; labial palpi 3-segmented. Relative proportions: HW 66; FV 21; POL 9; OOL 2.5; OCL 4; EL 38; EW 32; MS 20; SL 23; SW 9.

Thorax without notaular lines; sculpture on mesoscutum fine, shallow reticulate to imbricate-reticulate, on scutellum slightly deeper and generally finer, especially towards apex; venation and setation at base of forewing as in Fig. 37; linea calva interrupted by only one or two setae; postmarginal vein of forewing almost absent. Relative proportions: FWL 171, FWW 71; HWL 110, HWW 27.

Gaster in critical point dried holotype about as long as thorax; hypopygium reaching about two-thirds along gaster; ovipositor hidden. Relative proportions (paratype): OL 70; GL 11 [MT 84].

MALE. Almost identical to female but for structure of antenna (Fig. 36) and genitalia (Fig. 128). Flagellum uniformly pale brown; toruli with arrangement of associated sensilla as in Fig. 129. Relative measurements: AL 30; MT 68.

VARIATION. Very little in material available, except that linea calva may be entire or interrupted by one or two setae.

Host. Reared from leaf pit-galls of *Trioza nomei* Brown & Hodkinson on *Dendropanax* sp.

DISTRIBUTION. Costa Rica.

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, San José, Zurqui de Moravia, 1600m, ex galls of *Trioza nomei* Brown & Hodkinson on *Dendropanax* sp. i.1995 (P. Hanson). Paratypes: 4♀, 4♂, same data as holotype. Holotype and paratypes in BMNH, paratypes in INBio.

COMMENTS. We are unable to confirm that *M. gallicola* is parasitic on the gall-former since the parasitoids were reared from the collective galls of the trioizids and not individually from separated nymphs. There is a remote possibility that the parasitoids emerged from soft scales (Coccidae) that may have been overlooked, but this seems unlikely.

The generally blackish-brown and slightly shiny head and thorax separate *M. gallicola* from all other species of the genus known from the New World. Elsewhere the most similar species is the Palaearctic *M. nitens* (Kurdjumov), but this differs in a number of characters: most notably the angle formed by the ocelli, setation of the forewing, relative length of the postmarginal vein and coloration of the antenna, face and tegulae. In *nitens* the ocelli form an angle of about 45°, the linea calva is clearly interrupted by at least three lines of setae, the postmarginal vein is about half as long as the stigmal, the funicle segments are unicolorous testaceous-yellow, the face is entirely dark brown without a distinct transverse whitish line above the toruli and the bases of the tegulae are orange.

Metaphycus electra sp. nov.

(Figs 1, 38–40, 130–132)

DIAGNOSIS. Female (length (excluding ovipositor) 1.32–1.38mm): coloration as in Fig. 1 with head and dorsum of thorax mostly orange with dark markings on scape, occiput, pronotum, metanotum and propodeum; legs completely yellow; sides and venter of thorax and gaster pale yellow, almost white; dorsum of gaster dark brown; forewings hyaline; scape slightly less than 4 × as long as broad with a long, wide dark brown streak along dorsal margin in about middle; frontovertex slightly more than one-third head width; ocelli in an equilateral triangle; notaular lines reaching about half way across mesoscutum; hypopygium nearly reaching apex of gaster; ovipositor slightly exerted. Male (length 1.03–1.11mm): very similar to female except for the solid clava and genitalia structure.

FEMALE (HOLOTYPE). Length 1.32mm. Ocellar area orange; face below top of scrobes whitish; scape pale orange with a distinct, elongate, dark brown mark along its dorsal margin in middle and about half as long as scape; pedicel pale orange, proximally dark brown; F1–F4 brown, F5 and F6 yellowish, proximal segment of clava dark brown, apical segments yellow;

occiput with distinct, transverse dark brown line above foramen; face of pronotum dark brown, remainder whitish except for a pair of lateral dark brown spots; dorsum of thorax orange; metanotum dark brown; sides and venter of thorax pale whitish yellow; legs completely pale yellow; wings hyaline, venation testaceous brown; propodeum dorsally dark brown, medially whitish; basal tergite and venter of gaster whitish, dorsum dark brown to apex; exerted part of ovipositor whitish.

Head with regular, fine, reticulate sculpture of mesh slightly smaller than an eye facet; sculpture fine, but more irregular on lower parts of face; ocelli forming an angle of slightly more than 60°; eyes clothed in moderately conspicuous short setae; proportions of antennae as in Fig. 38; F5 and F6 and clava with longitudinal sensilla; mandible as in Fig. 132; maxillary palpi 3-segmented; labial palpi 3-segmented. Relative proportions: HW 69; FV 25; POL 10; OOL 4; OCL 5; EL 40; EW 33; MS 25; SL 31; SW 8.

Thorax with notaular lines about half way to posterior margin of mesoscutum; sculpture on mesoscutum fine, shallow reticulate to imbricate-reticulate, on scutellum slightly deeper and elongate reticulate, subapically polygonally reticulate; venation and setation at base of forewing as in Figs. 39 and 40. Relative proportions: FWL 195, FWW 80; HWL 125, HWW 33.

Gaster slightly shorter than thorax; hypopygium nearly reaching apex of gaster; exerted part of ovipositor about two-thirds as long as mid tibial spur. Relative proportions (paratype): OL 39; GL 11 [MT 41].

MALE. Generally very similar in appearance to female but for structure of antenna (Fig. 131) and genitalia (fig. 130). Flagellum uniformly pale brown; toruli apparently without associated sensilla. Relative measurements: AL 22; MT 37.

HOST. Supposedly reared from nymphs of *Trioza* sp. *magnoliae* group (det. D. Hollis) (Triozidae) forming closed galls on leaves of *Nectandra salicina*, although possibly parasitic on scale insects associated with these galls (see comments below).

DISTRIBUTION. Costa Rica.

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, Puntarenas, Monteverde, 1400m, ex galls of *Trioza* sp. *magnoliae* group (as sp. nr. *anceps* Tuthill) on *Nectandra salicina*, 1.iii.1991 (J. Blackmer). Paratypes: 1♀, 3♂, same data as holotype. Material in BMNH.

COMMENTS. The host of this species cannot be confirmed, although pupae within mummified nymphs collected together with the above mentioned material are certainly of encyrtids. These pupae are not com-

pletely formed, but the head structure seems closer to that of a species of *Psyllaephagus*, perhaps *trioziaphagus*, than to the present species.

Metaphycus electra is close to *M. stomachosus*, a parasitoid of Coccidae from North America. Both species have the scape at least about 3 × as long as broad, slightly exerted ovipositor, frontoververtex at least about one-third head width, general body colour orange and completely yellow legs without brown markings, notaular lines distinct but not complete and similar antennae in both females and males. The two differ in the female in the coloration of the scape, occiput and gaster, the relative width of the scape, and the structure of the gaster. In *electra* the scape has a very conspicuous, well-defined dark brown dorsal streak, the occiput is largely blackish, the last tergite of the gaster is mostly dark brown, the scape is nearly 4 × as long as broad, the hypopygium very nearly reaches the apex of the gaster and the ovipositor is about as long as the mid tibia; whilst in *stomachosus* the brown mark on the scape is vague and inconspicuous, the occiput is entirely orange, the last tergite of the gaster is orange, the scape is only about 3 × as long as broad; the hypopygium reaches about three-quarters along the gaster and the ovipositor is at least one-quarter longer than the mid tibia. The males differ in coloration as in the females.

SECTILICLAVA Hoffer

Sectiliclava Hoffer, 1957: 55–56. Type species

Sectiliclava paliuri Hoffer, by original designation.

Parapsyllaephagus Robinson, 1961a: 117. Type species *Parapsyllaephagus adulticollis* Robinson, by original designation. Synonymy with *Sectiliclava* by Robinson, 1961c.

DIAGNOSTIC CHARACTERS. Female: general habitus squat; head and often thorax strongly metallic; occipital margin carinate; funicle 6-segmented; clava 3-segmented; mandibles with two teeth and a truncation or appearing to be transversely truncate at apex but with four short, oblique teeth; apical segment of foretarsus strongly enlarged; wings hyaline; marginal vein very short, almost absent, stigmal vein arising directly from submarginal; postmarginal short; hypopygium reaching apex of gaster; ovipositor a little more than half length of mid tibia and with gonostyli immovably fused to second valvifers. Male: generally similar to female but funicle segments relatively longer and clothed in elongate setae which are at least about 3 × as long as diameter of segments; genitalia with parameres and digiti subequal in length and width; aedeagus very slender.

BIOLOGY. Species of *Sectiliclava* are parasitic on adult psyllids. The life history has been described by

Robinson (1961b) for *Sectiliclava cleone* (Walker) (as *Parapsyllaephagus adulticolis* Robinson) in England. In this species the eggs are deposited in late June through the dorsal surface of the adult psyllid (*Psylla melanoneura* Förster and *P. affinis* Loew) abdomen. Eclosion of the first instar parasitoid larva takes place after five to seven days and it immediately starts feeding and migrates towards the venter of the host where it feeds selectively on the developing genitalia. Development of the parasitoid larva to the fifth and final instar takes seven or eight months and at that time the host becomes mummified. Pupation of the parasitoid occurs at this point. Almost one year after the egg was deposited, and 20 to 30 days after pupation, the adult parasitoid emerges through a circular hole cut in the posterior-dorsal integument of the abdomen of the host. The host normally migrates from its winter food plant (*Picea* or *Pinus*) to its summer food plant (*Crataegus*) in March or April, but parasitized hosts do not migrate, probably through lack of hormonal stimulus from the gonads which have been destroyed by the parasitoid larva. The next generation of adult psyllids returns to the winter food plant by the end of June whereupon some of them are parasitised by encyrtids that have emerged from the previous generation of psyllids.

DISTRIBUTION. Europe, North America, Mexico, Costa Rica.

IDENTIFICATION OF SPECIES. See Robinson (1961a) for a description of the single, previously recognised species.

COMMENTS. *Sectiliclava* is very close to *Lochitoencyrtus*, a genus known only from the Neotropical region. The species of both genera have the marginal vein almost absent, similar mandibular structure and are parasitoids of psyllids. The two genera are separated here only on the presence of the enlarged apical segment of the fore tarsus of *Sectiliclava*, this segment being of more normal proportions in *Lochitoencyrtus*. This enlargement may be an adaptation for gripping adult psyllids during oviposition.

Key to Costa Rican species of *Sectiliclava*

(FEMALES)

- 1 Thorax and gaster entirely dark brown without any pale yellow or orange areas; coxae dark brown; funicle segments quadrate or transverse (Fig. 41) *pulchriceps* (p. 122)
- Thorax mostly yellow or orange; coxae yellow; funicle with at least proximal segments longer than broad (Fig. 42) *isis* (p. 123)

Sectiliclava pulchriceps sp. nov.

(Figs 41, 133, 134)

DIAGNOSIS. Female (length 1.03mm): frontovertex coppery-purple with highly contrasting, bright metallic green piliferous punctures; mesoscutum clothed in conspicuous silvery setae; all funicle segments quadrate or slightly transverse (Fig. 41); mandibles with four short, oblique teeth (Fig. 133); foretarsus with apical segment very enlarged and about as long as other four segments combined; hypopygium apically produced to enclose the ovipositor and reaching apex of gaster.

FEMALE (HOLOTYPE). Frontovertex deep coppery-purple with highly contrasting, bright metallic green piliferous punctures; scape yellow; pedicel yellow, brownish proximally; flagellum brown; mesoscutum blackish with a slight brassy and purple lustre and clothed with conspicuous silvery setae, especially in its posterior half or so; tegulae dark brown with bases yellow; scutellum deep coppery purple, apex and sides shining metallic green; wings hyaline, venation testaceous-yellow; coxae dark brown; femora brown with apices yellow, fore femora palest, hind femora darkest; tibia and tarsi yellow; propodeum brown, sides clothed in dense silvery setae; gaster dark brown, dorsally with a green, coppery and purplish lustre.

Frontovertex with very conspicuous piliferous punctures, each separated by less than their own diameters; sculpture between piliferous punctures fairly regular, raised and polygonally reticulate with mesh size about 2 × that of an eye facet; relative proportions of antenna as in Fig. 41; antennae separated from mouth margin by less than the diameter of an ocellus; ocelli forming an obtuse triangle; eyes with moderately dense, inconspicuous, short, translucent setae; mandibles appearing almost apically transversely truncate but with four short, obtuse teeth. Relative measurements: HW 79; FV 37.5; POL 25; OOL 2; OCL 4.5; EL 47; EW 35; MS 29; SL 27; SW 7.

Mesoscutum with raised, shallow, regular, imbricate reticulate sculpture, tending to polygonally reticulate posteriorly; scutellum very convex and medially with similar, but conspicuously deeper, sculpture to mesoscutum, towards sides more elongate or striate-reticulate; extreme sides and apex smooth and polished; venation and setation at base of forewing similar to that of *isis* (Figs 43 and 44) but setae in basal cell numbering fewer than 20; apical segment of fore tarsus conspicuously enlarged (as in Fig. 2); propodeal spiracle fairly large and touching anterior margin of propodeum. Relative measurements: FWL 175, FWW 80; HWL 116, HWW 38.

Gaster about as long as thorax; hypopygium with a narrow, median extension posteriorly which reaches the apex of the gaster and encloses the ovipositor;

gonostyli (Fig. 134) completely fused with second valvifers; ovipositor about $0.4 \times$ as long as mid tibia.

MALE. Unknown.

HOSTS. Unknown.

DISTRIBUTION. Costa Rica, Trinidad (West Indies).

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, Guanacaste, Barra Honda NP, 150m, v.1988 (I.D. Gauld). Paratype, **Trinidad**, 1♀, St. George, St. Augustine, wasteground, 16.vi.1976 (J.S. Noyes). Holotype and paratypes in BMNH.

COMMENTS. This is the species recorded from Trinidad as *Lochitoencyrtus* by Noyes (1980) and *Lochitoencyrtus gahani* by De Santis & Fernandes (1989).

S. pulchriceps can be separated from *isis* by the characters given in the key and from the only other described species of the genus, *cleone*, by the proportions of the funicle segments, presence of deep piliferous punctures on the frontovertex, mandibular structure and strongly convex scutellum. In *cleone*, FI–3 are clearly longer than broad, the piliferous punctures of the frontovertex are shallow and indistinct, the mandible has one tooth conspicuously longer than the others and sometimes appears to have only two teeth and a lower truncate part, and the scutellum is dorsally hardly convex.

Sectiliclava isis sp. nov.

(Figs 2, 42–44, 135)

DIAGNOSIS. Female (length 1.41–1.59mm): head generally metallic blue-green, face marked with purple; punctures conspicuous, but not highly contrasting; mesoscutum clothed in dark brown setae; all funicle segments longer than broad, sixth subquadrate (Fig. 42); foretarsus with apical segment very enlarged and about as long as other four segments combined (Fig. 2); hypopygium apically produced to enclose the ovipositor and reaching apex of gaster, or very nearly so. Male (length 1.57mm): similar to female but for antennae and genitalia.

FEMALE (HOLOTYPE). Length 1.59mm. Coloration generally as in Fig. 2; frontovertex with ocellar area metallic blue-green, below top of scrobes distinctly purplish; setae on frontovertex translucent and silvery white; radicle and scape yellow; extreme apex of scape, pedicel and flagellum testaceous brown; pronotum dorsally and anterior one-third or so of mesoscutum dark brown with a distinct metallic purple and green sheen; scutellum mostly metallic green, anteriorly purplish and medially coppery; metanotum dark brown; most of remainder of thorax, including legs pale yellow; mesopleuron pale orange, apical half of hind tibia dark brown; mesoscutum and axillae

clothed in dark brown setae posterior half or so; tegulae apically pale orange-brown with bases yellow; scutellum metallic green, purplish anteriorly and coppery medially, the sides metallic purple; wings hyaline, venation testaceous-yellow; propodeum, except medially brown, sides metallic green and clothed in dense silvery setae; gaster, including basal tergite, pale orange but with apical tergite bright metallic green, remaining tergites brown dorsally; median apical part of hypopygium, second valvifers, third valvulae and outer plates of ovipositor conspicuously dark brown.

Frontovertex with very shiny, conspicuous, confluent, piliferous punctures, each giving rise to a slightly flattened seta; relative proportions of antenna as in Fig. 42; antennae separated from mouth margin by a little more than diameter of an ocellus; ocelli forming a slightly obtuse triangle; eyes appearing naked but with moderately dense, inconspicuous, short, translucent setae. Relative measurements: HW 96; FV 39; POL 28; OOL 2; OCL 6; EL 55; EW 43; MS 34; SL 46; SW 8.

Mesoscutum with raised, shallow, regular, imbricate reticulate sculpture, tending to polygonally reticulate posteriorly; scutellum very convex and medially with similar, but conspicuously deeper sculpture than mesoscutum, towards sides more elongate or striate-reticulate; extreme sides and apex quite smooth; venation and setation at base of forewing as in Figs 43 and 44; apical segment of fore tarsus conspicuously enlarged (Fig. 2); propodeal spiracle fairly large, broadly oval and touching anterior margin of propodeum. Relative measurements: FWL 258, FWW 111; HWL 163, HWW 58.

Gaster a little more than two-thirds as long as thorax; hypopygium with a narrow, median extension posteriorly which more or less reaches the apex of the gaster and encloses the ovipositor; gonostyli (Fig. 135) completely fused with second valvifers.

MALE. Very similar to female but for antennae (Fig. 45) and genitalia. Frontovertex slightly broader than in female, nearly half head width.

HOSTS. Unknown, but possibly *Mitrapsylla* sp. B (Brown & Hodkinson, 1988), the only species which has been collected in Costa Rica in the same Malaise traps as the type material listed below (D. Hollis, pers. comm.).

DISTRIBUTION. Costa Rica.

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, Puntarenas, RF Golfo Dulce, 24 Km W. of Piedras Blancas, 200m, i–iii.1991 (P. Hanson). Paratypes: 1♀, 2♂, same data as holotype but iv–v.1991, ii.1992 and i–ii.1993. Holotype and paratypes in BMNH.

COMMENTS. A highly distinctive species which can

be separated from all other Neotropical species of Encyrtidae associated with psyllids by the strongly contrasting colours of the head, thorax and abdomen (see Fig. 2). Other species tend to be more uniformly coloured.

PRIONOMITUS Mayr

Prionomitus Mayr, 1876: 701. Type species *Encyrtus chlorinus* Dalman, by monotypy.

DIAGNOSTIC CHARACTERS. Female: body generally metallic green, often with purplish markings on face; funicle 6-segmented; clava 3-segmented; mandibles with one tooth and a broad, slightly concave truncation (Fig. 137); mesoscutum with a characteristic lateral submarginal depression or invagination more or less adjacent to each tegula; marginal vein short, very nearly punctiform, postmarginal distinct, at least about half as long as stigmal; gaster usually with hypopygium extending past apex of last tergite and enclosing ovipositor virtually to its apex. Male: generally similar to female but antenna with segments elongate, but asymmetric, the proximal segments subserrate, all segments with whorls of long setae at least about $3 \times$ as long as diameter of segments; genitalia with digiti well-developed and each with from two to four apical teeth.

BIOLOGY. Of the described species, hosts are known only for *P. miratus* and *tiliaris*. In the Palaearctic region these species have been recorded from *Psylla* spp. and in the Nearctic region from *Arytaina* spp. and *Pexopsylla* spp. The life history and host preferences in southern France have been described for *P. miratus* by Delvare (1984), Delvare, *et al.* (1981) and Nguyen & Delvare (1982). The eggs are normally deposited in the fourth instar of one of five species of *Psylla* and adults parasitoids emerge from the fifth. There are normally three generations of the parasitoid per year and the winter is passed in the adult stage with ovipositing commencing the following year in May. The deposited egg has a long peduncle which remains protruding through the integument of the host, but there is no distinct aeroscopic plate. Development of the embryo lasts about 2.5 days at 20°C. The enclosed larva lies orientated with its head end towards the posterior of the host and has 13 postcephalic segments. The first two larval instars are probably apneustic and remain attached to the integument of the host via the remains of the egg. The third instar is free and has 7 pairs of spiracles located on segments II to VII. The fourth instar has an additional pair of spiracles on segment IX. The fifth instar fills almost the whole of the body cavity of the host and has spiracles on each of segments II to X and in addition seven pairs of papillary sensory organs on the head. At this point, about 12–13 days after

oviposition, the host become mummified and after a further 18–20 days the adult parasitoid emerges.

USE IN BIOCONTROL. *Prionomitus miratus* (Dalman) has been introduced into Canada (British Columbia) and USA (California) in an attempt to control *Psylla pyricola* a pest of pears. It has been partially successful in controlling this pest in Canada (McMullen, 1971). In Europe, *P. miratus* is regarded as being important in the natural regulation of the same pest in southern France, and other countries (Delvare, *et al.*, 1981; Delvare, 1984).

DISTRIBUTION. The genus is found throughout the Holarctic region, Pakistan (BMNH) and central America (Mexico and Costa Rica).

IDENTIFICATION OF SPECIES. Trjapitzin (1989) provides a key to six of the seven described species from the Palaearctic region.

COMMENTS. *Prionomitus* was not included in the key to Neotropical genera of Encyrtidae (Noyes, 1980). In this key females would probably run best to couplet 171 and *Psyllaephagus*. It can be separated from *Psyllaephagus* using the characters given in the key to genera above. The male does not run easily in the key to males, but can generally be separated from all other known Neotropical encyrtid genera by the combination of very long setae on the antennal funicle which is somewhat serrate in appearance, the almost edentate mandibles and the characteristic lateral depressions on the mesoscutum.

Prionomitus miratus (Dalman)

(Figs 46, 47, 136, 137)

Encyrtus miratus Dalman, 1820: 352. Holotype, Sweden, NHMS, not examined.

Encyrtus chlorinus Dalman, 1820: 364. Synonymy with *Encyrtus miratus* Dalman by Thomson, 1876. Holotype ♀, Sweden, NHMS, not examined.

Encyrtus coniferae Walker, 1837: 461. Lectotype, designated by Graham, 1969: 245, Ireland, NMID. Synonymy with *Prionomitus miratus* (Dalman) by Graham, 1969.

Microterys miratus (Dalman); Thomson, 1876: 162.

Prionomitus miratus (Dalman); Mercet, 1921: 257.

DIAGNOSIS. Fore legs, including coxae completely yellow. Female (Length 1.10–1.90mm): head with a transverse purple band across top of antennal scrobes; antennae as in Fig. 46; ocelli forming an angle of 90° or more, the posterior ocelli equidistant from occipital and eye margins or distinctly closer to eye margins depending on relative width of frontovertex which varies from about one-third to two-fifths head width; forewing venation as in Fig 47; hypopygium extending past apex of last tergite and enclosing ovipositor which is about as long as mid tibia, gonostyli about

two-fifths as long as ovipositor. Male (length 0.98–1.60mm): similar to female but for antennae (Fig. 48) and genitalia (Fig. 136); aedeagus slightly more than half as long as mid tibia.

HOSTS. Not known for Costa Rica, but elsewhere reared from a variety of psyllid nymphs including Palearctic records from *Psylla pyri*, *P. pyrisuga*, *P. crataegi*, *P. peregrina*, *P. pyricola*, *P. retamae*, *P. melanoneura*, and Nearctic records from *Arytaina essigi*, *A. fuscipennis*, *A. insolita*, *A. robusta*, *A. minuta*, *Pexopsylla cereocarpi*, *P. americana* (see Trjapitzin, 1989). Also recorded below from *Livilla variegata* (Löw) on *Laburnum*.

DISTRIBUTION. Holarctic, Costa Rica.

MATERIAL EXAMINED.

Non type material. **Costa Rica**, 1♀, San José, Cerro de la Muerte, Arroyo Muerte, 3200m, 7–13.iv.1985 (L. Masner); 1♀, Hwy 2, km 93, [Cerro de la Muerte], 83°45'W 9°36'N, 3,200m, 1–7.iv.1985 (H. Goulet, L. Masner). **Canada**, 6♀, Ontario, Gloucester, x.1984 (M. Sanborne); 3♀, Hamilton, vii.1980, vii.1981, x.1984 (M. Sanborne); 1♀, Quebec, Gatineau Park, 23–30.viii.1982 (L. Masner); **Wales**, Pembs, Mynachlog-Ddu, 23.vi.1977 (J.S. Noyes, Z. Boucek); **Scotland**, 1♀, Fife, Tentsmuir Nat. Res., 16.vii.1977 (J.D. Noyes); **England**, 1♂, Bucks, Burnham Beeches, 7.ix.1975 (Z. Boucek); 1♀, Surrey, Kew, on *Tilia* sp., 14.v.1977 (V.F. Eastop); 1♂, Norfolk, Foulton Common, 5.ix.1977 (J.S. Noyes); 1♀, 6♂, Middlesex, ex *Floria variegata* Löw on *Laburnum*, 20.vi.1979 (R. Madge); **France**, 4♀, 1♂, Chateau-Arnoux, 10.viii.1972 (Z. Boucek); **Spain**, 3♀, Tarragona, Salou, 11.vi.1973 (Z. Boucek); 2♀, Granada, La Herradura, 24.vi.1973 (Z. Boucek); 1♂, Granada, Otivar, 25.vi.1973 (Z. Boucek); 1♂, Ciudad, Real Puerto Lapice, 27.vi.1973 (Z. Boucek); 1♀, 1♂, Madrid, El Pardo, 29.vi.1973 (Z. Boucek); 2♀, 8♂, Santander, Castro Urdiales, 2.vii.1973 (Z. Boucek); 4♂, Barcelona, Callella d. Costa, 20.vi.1974 (Z. Boucek); 1♀, Madrid, Casa de Campo, 15.x.1978 (J.S. Noyes); **Italy**, 1♀, Genova, Varazze, 4.ix.1971 (Z. Boucek); 3♀, Bolsena, Lago, 27.viii.1972 (Z. Boucek); **Montenegro**, 1♀, Crna Gora, Durmitor, Zabljak, 7.vii.1958 (Z. Boucek). Material in BMNH, INBio, CNC.

COMMENTS. This is a surprising locality for this species and must represent the extreme limits of its range in the New World.

PSYLLAEPHAGUS Ashmead

Psyllaephagus Ashmead, 1900: 382. Type species *Encyrtus pachypsyllae* Howard, by original designation.

Mirocerus Ashmead, 1904: 309. Type species

Mirocerus peyela Ashmead, by original designation. Synonymy with *Psyllaephagus* by Graham, 1969.

Calocerineloides Girault, 1913: 111. Type species *Calocerineloides ramosa* Girault, by original designation. Synonymy with *Psyllaephagus* by Noyes & Hayat, 1984.

Epanagyrus Girault, 1915: 160. Type species *Epanagyrus punctatiscutum* Girault, by original designation. Synonymy with *Psyllaephagus* by Noyes & Hayat, 1994.

Anagyropsis Girault, 1917: 136. Type species *Anagyropsis purpureus* Girault, by original designation. Synonymy with *Psyllaephagus* by Noyes & Hayat, 1994.

Metaprimonitus Mercet, 1921: 260. Type species *Metaprimonitus intermedius* Mercet, by original designation. Synonymy with *Psyllaephagus* by Trjapitzin, 1967.

Shakespeareia Girault, 1928: 3. Type species *Shakespeareia flabellata* Girault, by monotypy. Synonymy with *Psyllaephagus* by Noyes & Hayat, 1984.

Psyllecyrtus Tachikawa, 1955: 63. Type species *Psyllecyrtus syntomozae* Tachikawa, by original designation. Synonymy with *Psyllaephagus* by Tachikawa, 1981.

Calluniphilus Erdős, 1961: 413. Type species *Calluniphilus vendicus* Erdős, by monotypy. Synonymy with *Psyllaephagus* by Graham, 1969.

Ooencyrtoides Hoffer, 1963: 568. Type species *Ooencyrtus albopilosus* Hoffer, by original designation, as subgenus of *Ooencyrtus*. Synonymy with *Psyllaephagus* by Graham, 1969.

Propsyllaephagus Blanchard in De Santis, 1964: 235. Type species *Propsyllaephagus trellesi* Blanchard, by original designation. Synonymy with *Psyllaephagus* by Noyes, 1979.

Mercetia Bakkendorf, 1965: 139. Type species *Copidosoma lusitanicum* Mercet, by original designation. Synonymy with *Psyllaephagus* by Graham, 1969.

Kaszabicyrtus Szelenyi, 1971: 389. Type species *Kaszabicyrtus acutigastris* Szelenyi, by original designation. Synonymy with *Psyllaephagus* by Trjapitzin & Gordh, 1978.

DIAGNOSTIC CHARACTERS. About 1–2mm long; males and females generally similar but for antennae and genitalia; head and thorax in most species metallic green; occipital margin rounded not sharply carinate; mandibles with only a few exceptions with one tooth and a broad, straight truncation; marginal vein punctiform, or hardly longer than broad (some Australian species known with marginal vein conspicuously longer than broad); postmarginal vein well-developed; lineae clava not interrupted; mesoscutum laterally with-

out conspicuous pits or depressions anterior to tegulae; axillae touching; mesopleuron not strongly expanded posteriorly, in side view clearly separated from base of gaster by propodeum. Female: funicle 6-segmented, clava 2- or 3-segmented; hypopygium not reaching apex of gaster; ovipositor hidden to well-exserted. Male: funicle 6-segmented, the segments varying from cylindrical with very long setae to broadened and flattened with very short setae giving the flagellum a serrate appearance; clava entire; phallobase with well developed digiti each armed with from one to three apical hooks.

BIOLOGY. Where their biology is known all species are primary endoparasitoids of the nymphs of Psyllidae and Triozidae (Hemiptera, Psylloidea). Some Australian species are reportedly hyperparasitoids (Riek, 1962), although this requires confirmation.

The life history has been described only for *P. euphyllurae*, a parasitoid of *Euphyllura olivina* Costa (Hemiptera: Psyllidae) in the Mediterranean region (Chermi, *et al.*, 1986). In this species most eggs are deposited within the thorax of the 4th or 5th instar of the host. Each egg remains attached to the integument of the host by a partly sclerotised peduncle which passes through the integument of the host. The host has no immune response to the egg. The larva hatches after two days and stays attached to the egg. After one or two days the larva becomes free and moves towards the rear of the host. Early instar parasitoid larvae feed on the fat body of host for seven or eight days and then for one or two days on internal organs after the host becomes mummified. Mummification occurs about eight or nine days after oviposition.

USE IN BIOCONTROL. Only *Psyllaephagus yaseeni* (see below) and *P. pilosus* Noyes have been used in classical biological control programmes. *P. pilosus*, a native of Australia, has been introduced into California (USA) and Wales (UK) in an attempt to control *Ctenarytaina eucalypti* (Maskell) a pest of *Eucalyptus* spp. in California and Wales and a native of Australia (Hodkinson, 1994). Several other species of *Psyllaephagus* undoubtedly play an important role in the natural control of psyllid pests in the world. For instance *Psyllaephagus euphyllurae* (Masi) is a parasitoid of *Euphyllura olivina* (Costa), a pest of olive in the Mediterranean region and *Psyllaephagus pistaciae* Ferrière and *P. agonoscemae* Ferrière are parasitoids of *Agonoscena targionii* (Lichtenstein), a pest of pistachio in the middle east and Turkey.

DISTRIBUTION. A cosmopolitan genus containing over 200 described species. It is seemingly poorly represented in the New World where only 18 species are known, including those described below. The greatest number of species occur in Australia where

there are about 110 described species although there may be as many as 1,000 species (Noyes & Hayat, 1994). Nearly 60 species known from the Palaearctic region (Trjapitzin, 1989) and 22 species from Africa (Prinsloo, 1981). Little is known of the Oriental fauna, only a single described species is known, but several undescribed species have been examined (BMNH).

IDENTIFICATION OF SPECIES. The Palaearctic species have been keyed by Trjapitzin (1981, 1989) and the southern African species by Prinsloo, (1981). Noyes & Hayat (1984) provide a list of the species known from the Indo-Pacific region.

Key to Costa Rican species of *Psyllaephagus*

- 1 Tegulae yellow basally *othrys* (p. 127)
- Tegulae completely brown. 2
- 2 Females, clava three segmented. 3
- Males, clava entire 13

FEMALES

- 3 Scape yellow or amber and conspicuously paler than flagellum 4
- Scape mostly dark brown and not paler than flagellum 5
- 4 Ocelli forming an obtuse angle; antennal scrobes not unusually deep and separated from anterior ocellus more than the length of an antennal torulus; ovipositor not exerted *ufens* (p. 128)
- Ocelli forming an acute angle; antennal scrobes rather deep and elongate, separated from anterior ocellus by less than the length of a torulus; ovipositor clearly exerted, the exerted part more than half as long as mid tibial spur *domitius* (p. 129)
- 5 Frontoververtex with distinct piliferous punctures, each conspicuously larger than an eye facet 6
- Frontoververtex with piliferous punctures indistinct, not larger than an eye facet, usually somewhat obscured by the reticulate sculpture of the frontoververtex 7
- 6 Posterior ocelli a little closer to occipital margin than to eye; piliferous punctures relatively large, the largest about the same diameter as an ocellus *creusa* (p. 130)
- Posterior ocelli slightly closer to eye than to occipital margin; piliferous punctures smaller, the largest clearly smaller than an ocellus *gyces* (p. 131)
- 7 Either ovipositor well exerted, the exerted part more than half as long as the mid tibial spur, or the scutellum has sculpture conspicuously shallower than mesoscutum, sometimes quite smooth. 8
- Ovipositor not exerted, or if so then exerted part not more than half as long as mid tibial spur; scutellum with

- deeper sculpture than mesoscutum 9
- 8 All funicle segments longer than broad, clava with apex rounded and sutures transverse and subparallel *tyche* (p. 132)
- Funicle with F6 quadrate, clava with a slight oblique apical truncation, the sutures converging ventrally and distinctly oblique *trioziphagus* (p. 133)
- 9 Ocelli forming a strongly obtuse angle; scape shorter than minimum width of frontovertex 10
- Ocelli forming an angle of about 90°; scape at least as long as minimum width of frontovertex 11
- 10 Posterior ocelli slightly closer to eyes than to occipital margin, separated from latter by about their own diameters; mesoscutum metallic green *epulo* (p. 134)
- Posterior ocelli about equidistant from eye and occipital margin, separated from latter by much less than their own diameters; mesoscutum with only a very weak metallic sheen. *thonis* (p. 135)
- 11 Mesoscutum rather dull metallic green and not more shiny than scutellum; sculpture of scutellum rather finely reticulate, the cells not arranged in indistinct whorls or longitudinal lines *alexion* (p. 136)
- Mesoscutum bright metallic green, conspicuously more shiny than scutellum; sculpture of scutellum coarsely reticulate, the cells appearing to be arranged in lines or indistinct whorls 12
- 12 Mid tibia with subbasal ring very indistinct or absent; hind tibia with proximal dark brown area diffuse and extending only about half way; combined length of pedicel and flagellum greater than head width *rotundiformis* (p. 137)
- Mid tibia with a distinct, dark brown, subbasal ring; hind tibia with basal three-quarters or so dark brown; combined length of pedicel and flagellum less than head width *yaseeni* (p. 138)

MALES

- 13 Frontovertex with deep, conspicuous, piliferous punctures which are separated by less than their own diameters and extend downwards between the antennal scrobes and eyes; posterior ocelli much closer to occipital margin than to eye, separated from occipital margin by about one-third their own lengths and from eye by about their own lengths *creusa* (p. 130)
- Frontovertex without conspicuous piliferous punctures, if present small and separated by much more than their own diameters and hardly extending below anterior ocellus; posterior ocelli about equidistant from occipital and eye margins 14
- 14 First funicle segment relatively short and broad, less than 1.5 × as long as broad 15
- First funicle segment at least about twice as long as broad 16
- 15 Antenna with F6 at least 1.35 × as long as broad; basal

- cell of forewing with at least 50 dorsally *rotundiformis* (p. 137)
- Antenna with F6 not more than 1.25 × as long as broad; basal cell of forewing with not more than 40 setae dorsally *yaseeni* (p. 138)
- 16 Sculpture of scutellum relatively shallow, sometimes almost smooth, and never deeper than that on mesoscutum; smaller species: <1.2mm *trioziphagus* (p. 133)
- Scutellum with conspicuous reticulate sculpture which in part is at least slightly deeper than that on mesoscutum; larger species: >1.5mm 17
- 17 Scape largely yellowish and clearly paler than flagellum; legs, except hind femur and coxae, mostly yellowish; frontovertex slightly less than half head width *ufens* (p. 128)
- Scape blackish brown, concolorous with flagellum; legs almost entirely blackish with some paler areas, especially apices of tibiae tarsi; frontovertex slightly more than half head width *epulo* (p. 134)

Psyllaephagus othrys sp. nov.

(Figs. 49–52, 139–141)

DIAGNOSIS. Female (length: 1.59–1.90mm): head largely bluish, dorsum of thorax bright metallic green; tegulae yellow basally; frontovertex with moderately conspicuous piliferous punctures; mesoscutum and scutellum with fine, punctate reticulate sculpture, slightly deeper and more longitudinally elongate on scutellum; marginal vein more or less absent. Female: all femora dark brown; all tibiae with a narrow, dark brown subbasal ring. Male (length: 1.40–1.62mm): legs as in female, but mid legs conspicuously paler and hind tibia darker.

FEMALE (HOLOTYPE). Length 1.82mm. Head on frontovertex metallic green, level with top of scrobes and below metallic blue, mouth margin green; antennae dark brown, almost black; dorsum of thorax metallic green, posterior margins of pronotum and mesoscutum and scutellum medially coppery; axillae dark purplish mixed coppery and brassy; tegulae yellow at base, otherwise dark brown; sides of pronotum and anterior part of prepectus dark metallic blue-green; posterior half of prepectus translucent yellow or orange; mesopleuron anteriorly coppery purple, posteriorly metallic green; sides of propodeum metallic green; coxae dark brown with metallic green reflections; femora concolorous but with apices of fore and mid femora amber, distal apex of hind femur slightly paler; fore and hind tibiae concolorous with coxae in basal half, distal half amber; mid tibia pale amber with a narrow dark brown subbasal ring; tarsi amber, foretarsi slightly darker; wings hyaline, venation pale brown; gaster dark brown with metallic purple and green sheen, basal tergite more

distinctly metallic green; visible part of gonostyli dark brown.

Frontovortex with moderately conspicuous, shallow piliferous punctures each separated by their own diameters or a little more, between these sculpture finely reticulate; between scrobes and eye margins and on genae, piliferous punctures not distinct and sculpture more longitudinally elongate; posterior ocelli slightly nearer eyes than to occipital margin; eyes virtually naked; antennal toruli with their mid-line about level with lowest eye margins; mandibles (Fig. 139) with two teeth and a truncation; pedicel plus flagellum about as long as head width; proportions of antenna as in Fig. 49. Relative measurements: HW 100; FV 42; POL 25; OOL 4.5; EL 59; EW 42; MS 25; SL 41; SW 9.

Mesoscutum with fairly regular, reticulate sculpture similar to that of frontovortex; sculpture on scutellum similar but clearly longitudinally elongate and much shallower towards sides and apex; axillae almost smooth; metapleuron and sides of propodeum clothed in conspicuous, pale, translucent setae; setation on base of forewing and venation as in Figs 50 and 51. Relative measurements: FWL 270, FWW 110; HWL 168, HWW 56.

Gaster shorter than thorax with ovipositor (Fig. 140) hardly exerted, the exerted part about half as long as mid tibial spur; hypopygium reaching to about three-quarters along gaster. Relative measurements (paratype): OL 98; GL 18 [MT 56].

MALE. Generally similar to female but for antennae (Fig. 52), genitalia (Fig. 141), wider frontovortex and higher placement of antennae. Antennal toruli with ventral margins level with, or even slightly higher than, lowest eye margins. Relative measurements: HW 64; FV 33; SL 15.5; MT 55; AL 46.

VARIATION. Very little in material available.

HOSTS. Reared from nymphs of *Euphalerus certus* Tut. forming galls on *Lonchocarpus atropurpureus* (Leguminosae: Mimoseae).

DISTRIBUTION. Costa Rica (San José).

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, San José, San Pedro de Montes de Oca, 1100m, ex *Lonchocarpus* psyllid gall, 17.viii.1987 (P. Hanson). Paratypes: **Costa Rica**, 1♀, San José, San Pedro de Montes de Oca, agalla de *Lonchocarpus atropurpureus*, 22.vii.1987 (P. Hanson); 12♀, 11♂, San Jose, San Pedro, Montes de Oca, 1100m, 20.ii.1988 (P. Hanson); 1♀, 2♂, same data but *Lonchocarpus* gall (P. Hanson). Holotype in BMNH, paratypes in INBio, CNC, USNM, UCR.

COMMENTS. *Psyllaephagus othrys* is superficially

similar to *pachypsyllae* (Howard) known from North America. Both sexes of *othrys* can be separated from those of *pachypsyllae* by the absence of the marginal vein and the tibiae being extensively marked with dark brown. In *pachypsyllae* the marginal vein is clearly present, quadrate or slightly longer than broad, and the tibiae are almost entirely yellow.

We have examined three specimens from Belize (Cayo, Chiquibul Forest, ex leaves of *Lonchocarpus rugosus* galled by *Euphalerus* sp. nov, 4–8.iii.1995 (D. Hollis) (BMNH). These specimens may belong to *othrys* but differ significantly in the antenna of the male being relatively more slender (all funicle segments clearly little longer than broad, whilst in the paratype males of *othrys* F3 is strongly transverse and F2 and F4 are subquadrate), and the hind tibiae less extensively marked with dark brown.

Psyllaephagus ufens sp. nov.

(Figs 54–58, 138)

DIAGNOSIS. Female (length: 1.5–1.87mm): head black with a slight metallic sheen; scape yellowish, much paler than the brown flagellum; mesoscutum similar but with a slightly stronger metallic sheen than head; scutellum distinctly metallic coppery and blue; tegulae brown; legs with femora dark brown, tibiae yellowish or with a faint brown subbasal ring, stronger on hind tibiae; antennal scrobes moderately deep but separated from anterior ocellus by more than the length of a torulus; ocelli forming an obtuse angle; piliferous punctures on frontovortex shallow and indistinct; sculpture of mesoscutum shallow, that on scutellum distinctly deeper; marginal vein punctiform; ovipositor not exerted. Male (length about 1.7mm): antenna with scape yellowish and clearly paler than flagellum; legs mostly yellowish; F1 funicle segment at least twice as long as broad; frontovortex slightly less than half head width; sculpture on scutellum at least slightly deeper than that on mesoscutum.

FEMALE (HOLOTYPE). Length 1.87mm. Head on frontovortex black with a slight brassy, green and purplish sheen; scrobal area dull metallic green, but with a distinct blue and purple sheen on dorsal part of interantennal prominence and on genae; mouth margin dark coppery purple medially; scape yellow or testaceous-yellow, conspicuously paler than flagellum; pedicel mostly dark brown slightly metallic, with apex and venter yellow; flagellum brown to dark brown; mesoscutum predominantly blackish, with weak to moderate blue and purple reflections; scutellum dark purple-brown with a coppery sheen in basal two-thirds, sides and apex metallic blue-green; axillae dark brown, almost black, but with a weak purple and brassy sheen; tegulae dark brown; sides of thorax dark purple-brown; mesopleuron with a green and coppery

sheen; metapleuron metallic purple; sides of propodeum metallic blue-green; coxae dark brown with weak purple, blue and brassy reflections; femora concolorous but marked with yellow at apices; tibiae completely yellow or with a faint subbasal brown anellus on mid tibia and basal one-third or so of hind tibia brown; tarsi completely yellow but with pretarsi brown; wings hyaline, venation yellow-brown; gaster dark brown with metallic purple, coppery and green sheen, basal tergite distinctly metallic blue-green mixed with some purple; visible part of gonostyli dark brown, but apically slightly paler.

Frontovertex with regular, raised, reticulate sculpture, finer in ocellar area; sculpture between eyes and scrobes less coarse and more regular; scrobal area, mouth margin and other areas with shallower sculpture and more shiny, sculpture on genae longitudinally elongate; antennal toruli separated from mouth margin by slightly more than their own lengths; scrobes moderately deep but separated from anterior ocellus by more than the length of a torulus; ocelli forming a slightly obtuse angle; posterior ocelli slightly to conspicuously closer to eye margins than to occipital margin; eyes with very short, inconspicuous setae, appearing naked; mandibles (Fig. 138) with one tooth and a broad, strongly concave truncation which gives the mandibles an almost tridentate appearance; pedicel and flagellum together as long as head width or nearly so; proportions of antenna as in Fig. 53. Relative measurements: HW 114; FV 46; POL 24; OOL 4; OCL 5.5; EL 66; EW 49; MS 34; SL 42; SW 9.5.

Mesoscutum with very similar sculpture to frontovertex; scutellum with similar, but slightly deeper, distinctly longitudinally elongate, reticulate sculpture, extreme sides posteriorly, and apex smooth and shiny; axillae with shallow, reticulate sculpture; metapleuron and sides of propodeum clothed in relatively conspicuous, silvery, translucent setae; setation on base of forewing and venation as in Figs 54 and 55. Relative measurements: FWL 293, FWW 135; HWL 193, HWW 65.

Gaster slightly shorter than thorax, ovipositor (Fig. 57) not exerted; hypopygium reaching about half way along gaster.

MALE. Very similar to female but for wider frontovertex, smaller eyes, higher placement of antennal toruli, and structure of antennae (Fig. 58) and genitalia. Frontovertex very nearly half head width (HW: FV = 69: 32); antennal toruli separated from mouth margin by only slightly less than twice their own lengths.

VARIATION. There is a little variation in coloration, the paratypes have the darker areas of the mid femora and hind tibiae less extensive than described for the holotype. There is also slight variation in the relative length of the marginal vein of the female (compare

Figs 55 and 56).

HOSTS. Unknown, but reared from trioizid galls (almost certainly *Trichohermes magna* (Laing), D. Hollis, pers. comm.) on *Pseudolmedia oxyphillarya*.

DISTRIBUTION. Costa Rica.

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, San José, Zurqui de Moravia, 1600m, i-ii.1992 (P. Hanson). Paratypes: **Costa Rica**, 1♀, Cartago, Turrialba, CATIE, Reventazon, 550m, 4.ix.1985 (L. Masner); 3♀, 1♂, Puntarenas, Monteverde, *Pseudolmedia oxyphillarya*, vii.1994 (D. Briceño). Holotype and paratypes in BMNH, paratypes in INBio and CNC.

COMMENTS. *P. ufens* is superficially very similar to *thonis* and *alexion*, all three species being of similar habitus, antennal structure and coloration. The species can be separated on the coloration of the scape (see key) and on the shape of the mandible. In *ufens* the mandible is very nearly tridentate, whilst in *thonis* and *alexion* the truncate part is straight and broad (see Fig. 145). *P. ufens* is also similar to *domitius* (see comments under *domitius*).

Psyllaephagus domitius sp. nov.

(Figs 60–61)

DIAGNOSIS. Female (length, excluding ovipositor: 2.35mm): head generally metallic green with a purple sheen in ocellar area; scape amber mixed with brown along dorsal margin, clearly paler than dark brown flagellum; mesoscutum blackish with a dull metallic blue sheen; scutellum similar but coppery basally; tegulae brown; legs with fore and hind femora dark brown, mid femora and tibiae yellowish, but brown along posterior margin; gonostyli yellow; piliferous punctures on frontovertex shallow and indistinct, but quite distinct on genae; antennal scrobes deep and long, separated from anterior ocellus by about the length of a torulus; sculpture of mesoscutum shallow and similar to that on scutellum; marginal vein more or less punctiform; ovipositor clearly exerted. Male: unknown.

FEMALE (HOLOTYPE). Head generally dark metallic green with some purple reflections, especially in ocellar area and with scrobes quite shiny; scrobes dorsally metallic blue-green, margined with purple; mouth margin dark coppery purple medially; scape amber, mixed brown along dorsal margin; pedicel amber ventrally and dark brown dorsally; flagellum dark brown, almost black; mesoscutum predominantly blackish, with weak to moderate blue sheen, margined dark coppery purple; scutellum dark purple-brown with a coppery sheen in basal half or so, apex and sides metallic green; axillae concolorous with base of

scutellum; tegulae dark brown; sides of thorax dark purple-brown; mesopleuron with a green and coppery sheen; metapleuron metallic purple; sides of propodeum metallic blue-green; coxae dark brown; fore and hind femora concolorous with coxae but marked amber at apices; fore and mid tibiae amber, but mid tibiae with a faint subbasal brown ring; hind tibiae mostly brown with apices amber; tarsi yellow-amber to amber, paler proximally; wings hyaline, venation brown; gaster dark brown with metallic purple, coppery and green sheen, basal tergite distinctly metallic blue-green mixed with some purple; visible part of gonostyli yellow-amber, apically slightly paler.

Frontovertex with regular, fine, raised, almost transversely striate, reticulate sculpture; between eyes and scrobes sculpture similar, but more longitudinally elongate; scrobal area, mouth margin and other areas with shallower sculpture and more shiny, sculpture on genae longitudinally elongate; antennal toruli separated from mouth margin by about their own lengths; scrobes deep and elongate, separated from anterior ocellus by less than the length of a torulus; posterior ocelli much closer to eye margins than to occipital margin; eyes appearing naked; mandibles with two teeth and a truncation; flagellum slightly shorter than head width; proportions of antenna as in Fig. 59. Relative measurements: HW 120; FV 32; POL 16; OOL 2; OCL 11; EL 71; EW 58; MS 43; SL 51; SW 11.5.

Mesoscutum with very similar sculpture to frontovertex; scutellum with similar sculpture, but appearing coarser basally and with slightly larger, more polygonal mesh, especially in apical half; axillae with shallow, reticulate sculpture; metapleuron and sides of propodeum clothed in relatively conspicuous, silvery, translucent setae; setation on base of forewing and venation as in Figs 60 and 61. Relative measurements: FWL 263, FWW 102; HWL 178; HWW 20.

Gaster in Critical Point Dried holotype slightly longer than thorax, ovipositor clearly exerted, the exerted part slightly longer than half length of mid tibial spur; hypopygium reaching about two-thirds along gaster.

MALE. Unknown.

HOSTS. Unknown.

DISTRIBUTION. Costa Rica.

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, Guanacaste Pr., Guanacaste NP, Estacion Cacao, 950–1200m, 13.ii.1995 (L. Masner). Holotype in CNC.

COMMENTS. *P. domitius* can be separated from all other species of the genus known to us by the relatively very deep and elongate antennal scrobes which nearly reach the anterior ocellus. It is probably closest to *ufens*, but can be separated from this species by the

relatively wider frontovertex, smaller angle formed by the ocelli, the clearly exerted ovipositor and sculpture of the scutellum which is not deeper than that of mesoscutum (see relevant diagnoses and key to species).

Psyllaephagus creusa sp. nov.

(Figs 62–68, 142)

DIAGNOSIS. Head and thorax generally with a relatively dull metallic green or blue-green sheen; tegulae brown; scape brown; legs with femora and tibiae dark brown, apices of tibiae yellowish; frontovertex with very conspicuous piliferous punctures, each larger than an eye facet, mesoscutum and scutellum with similar, but slightly smaller punctures; posterior ocelli closer to occipital margin than to eyes; mesoscutum with very fine, punctate-reticulate sculpture, that on scutellum slightly deeper, irregular, and slightly elongate. Female (length: 1.52–2.29mm): ovipositor hidden. Male: length: 1.52–2.24mm.

FEMALE (HOLOTYPE). Length 2.14mm. Head on frontovertex metallic green, relatively dull and slightly bluish; antennal scrobes dorsally conspicuously purple, interantennal prominence and piliferous punctures below top of scrobes with purple reflections; antennae dark brown, almost black, apex of scape slightly paler; dorsum of thorax dull, metallic blue green; tegulae completely dark brown, almost black; sides of pronotum and prepectus dark brown, slightly metallic blue-green, with coppery reflections, especially on prepectus; mesopleuron dull metallic green with coppery and purple reflections; sides of propodeum dull metallic blue-green; coxae dark brown with metallic blue-green reflections; femora concolorous but distally narrowly amber; tibiae in proximal half or so concolorous with coxae, distally pale amber; tarsi pale amber; pretarsi dark brown; wings hyaline, venation brown, submarginal vein proximally conspicuously paler; gaster dark brown with metallic purple sheen, basal tergite distinctly metallic blue-green mixed with some purple; visible part of gonostyli dark brown.

Frontovertex with very conspicuous, hardly separate, piliferous punctures which give it an appearance similar to that of the surface of a golf ball, these punctures extending down to about level with top of antennal toruli; sculpture relatively shallow, but fairly regularly reticulate, even in the piliferous punctures; sculpture on genae, more irregular and transversely elongate; antennal toruli separated from mouth margin by about their own lengths; posterior ocelli slightly nearer occipital margin than to eyes; eyes virtually naked; mandibles with two teeth and a truncation; pedicel and flagellum together slightly shorter than head width; proportions of antenna as in Fig. 62. Relative measurements: HW 132; FV 60; POL 27;

OOL 10; EL 67; EW 48; MS 36; SL 43; SW 10.5.

Mesoscutum with similar sculpture to that of frontovortex, but reticulate sculpture deeper and more distinct and piliferous punctures shallower and smaller, and clearly separated from each other; sculpture on scutellum similar but slightly deeper and clearly longitudinally elongate, much shallower towards sides and apex; axillae almost smooth; metapleuron and sides of propodeum clothed in conspicuous, silvery, translucent setae; setation on base of forewing and venation as in Figs 63 and 64. Relative measurements: FWL 320, FWW 141; HWL 209, HWW 75.

Gaster shorter than thorax with ovipositor (Fig. 65) hidden; hypopygium reaching to nearly four-fifths along gaster. Relative measurements (paratype): OL 58; GL 11 [MT 72].

MALE. Generally similar to female but for antennae (Fig. 66), genitalia (Fig. 67, 68, 142), wider frontovortex and higher placement of antennae. Antennal toruli separated from mouth margin by about $1.5 \times$ their own lengths. Relative measurements: HW 73; FV 39; SL 12.5; MT 64; AL 35.

VARIATION. Very little in material available.

HOSTS. Reared from *Neolithus* sp. (Homoptera, Trioziidae) forming closed galls on leaves of *Sapium oligoneuron* (Euphorbiaceae).

DISTRIBUTION. Costa Rica (San Jose; 1400–1800m).

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, San José, 4 Km E San Jeronimo, ex *Neolithus* sp. in galls on *Sapium oligoneuron* collected 26.i.1993, emerged i–ii.1993 (D. Hollis, P. Hanson). Paratypes: **Costa Rica**, 2♀, 3♂, San José, 6 Km NE San Jeronimo de Moravia, Carr. Carillo, 1500m, ex gall of *Neolithus* sp. on *Sapium oligoneuron*, ii–v.1988 (P. Hanson); 3♀, ♂, San José, Zurqui de Moravia, psyllid gall (= *Neolithus*) on *Sapium oligoneuron*, 22.xii.1990 (P. Hanson); 7♀, 10♂, same data as holotype; 1♂, Puntarenas, Monteverde, 10°18'N 84°04'W, 1400m, ex psyllid gall (= *Neolithus*) on *Sapium oligoneuron*, v.1989 (K. Brodshaw). Holotype and paratypes in BMNH, paratypes in INBio, UCR.

COMMENTS. This species can be separated from other species of *Psyllaephagus* by the deep, conspicuous piliferous punctures of the frontovortex.

Psyllaephagus gyces sp. nov.

(Figs 69–71)

DIAGNOSIS. Female (length, excluding ovipositor: 1.23–1.58mm): head dull with a slight metallic green or blue lustre; scape brown, not paler than flagellum; mesoscutum similar to head and scutellum brighter metallic green; tegulae brown; legs with femora dark brown, tibiae mostly yellow with bases brownish;

frontovortex with conspicuous piliferous punctures, each conspicuously larger than an eye facet; posterior ocelli closer to eye than to occipital margin; sculpture on scutellum slightly deeper than that on mesoscutum; marginal vein punctiform; ovipositor slightly exerted.

FEMALE (HOLOTYPE). Length 1.23mm. Head on frontovortex between anterior ocellus and antennal scrobes metallic blue-green, postocellar area blackish with purple reflections; scrobal area purple with blue areas on interantennal prominence and clypeal margin; scape dark brown, slightly metallic, its apex yellowish; pedicel dark brown; flagellum brown; mesoscutum predominantly green but with strong blue and purple reflections; scutellum metallic green in basal area, but sides and apex tending to blue-green; axillae coppery purple; tegulae dark brown; sides of thorax dark purple-brown; sides of propodeum metallic blue-green; coxae dark brown with slight purple and brassy reflections; femora concolorous but marked with yellowish at apices; fore tibiae in proximal half or so concolorous with coxae, distally yellowish; mid and hind tibiae yellowish, each with a narrow brown basal ring; foretarsi brown; mid and hind tarsi yellow, hind tarsi a little darker with pretarsi brown; wings hyaline, venation yellow-brown; gaster dark brown with metallic purple and green sheen, basal tergite distinctly metallic blue-green mixed with some purple; visible part of gonostyli dark brown.

Frontovortex with conspicuous, hardly separate, piliferous punctures which give it an appearance similar to that of the surface of a golf ball, these punctures extending down to about level with top of antennal toruli; sculpture relatively shallow, but fairly regularly reticulate, even in the piliferous punctures; sculpture on genae, more irregular and transversely elongate; antennal toruli separated from mouth margin by about their own lengths; posterior ocelli about equidistant from eye and occipital margins; eyes with sparse, very short setae, appearing virtually naked; mandibles with two teeth and a truncation; pedicel and flagellum together slightly shorter than head width; other proportions of antenna as in Fig. 69. Relative measurements: HW 77; FV 33; POL 17; OOL 4; EL 45; EW 34; MS 20; SL 26; SW 7.

Mesoscutum with fine, imbricate-reticulate sculpture, perhaps slightly deeper than sculpture on frontovortex; scutellum with clearly deeper, longitudinally reticulate sculpture, extreme sides posteriorly, and apex smooth and shiny; axillae almost smooth; metapleuron and sides of propodeum clothed in relatively sparse, conspicuous, silvery, translucent setae; setation on base of forewing and venation as in Figs 70 and 71. Relative measurements: FWL 175, FWW 79; HWL 118, HWW 35.

Gaster slightly shorter than thorax with ovipositor slightly exerted, the exerted part nearly as long as

mid tibial spur; hypopygium reaching slightly more than two-thirds along gaster.

MALE. Unknown.

VARIATION. Very little except that in the paratypes the ovipositor is less distinctly exerted with the exerted part less than half as long as the mid tibial spur. There is also some slight variation in the coloration of the mesoscutum with one paratype having the mesoscutum dull metallic blue with a slight purple sheen.

HOSTS. Unknown but very probably parasitic on gall-forming nymphs of Triozidae (Homoptera).

DISTRIBUTION. Costa Rica, coastal.

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, Puntarenas, Golfito, 20.iii.1990 (J.S. Noyes). Paratypes: **Costa Rica**, 2♀, Puntarenas, Puerto Jimenez, 8°32'N 83°19'W, 10m, viii and xi.1991 (P. Hanson). Holotype and paratype in BMNH, paratype in INBio.

COMMENTS. *P. gyces* is close to *P. creusa*, both species having deep conspicuous, piliferous punctures on the frontovertex. The two species can be separated by the conspicuous size difference, relative width of frontovertex and position of posterior ocelli, sculpture of mesoscutum, sculpture of the scutellum and length of exerted part of ovipositor.

Psyllaephagus tyche sp. nov.

(Figs. 72–74)

DIAGNOSIS. Female (length: 1.75–2.16mm): head with a blue or green sheen; mesoscutum similar but more strongly metallic; scutellum with base coppery but otherwise similar to mesoscutum; scape brown, not paler than flagellum, except extreme apex which is yellow; tegulae brown; all femora dark brown; tibiae mostly yellowish but each basally with a narrow brown ring; eyes reaching occipital margin; all funicle segments longer than broad; clava with apex rounded, sutures transverse; frontovertex without conspicuous piliferous punctures; sculpture of mesoscutum and scutellum very similar, shallow; marginal vein very slightly longer than broad; ovipositor slightly exerted.

FEMALE (HOLOTYPE). Length 1.75mm. Head on frontovertex metallic blue-green, purplish on scrobal area to just below tops of toruli and on genae, lower parts of face green with blue reflections; scape and pedicel black with a slight metallic sheen, apical one-fifth of scape yellow; flagellum brown; mesoscutum relatively bright metallic green with a slight coppery sheen; scutellum in basal two-thirds coppery, apical part metallic green; axillae dark purplish-brown mixed coppery; tegulae dark brown; sides of pronotum and

anterior part of prepectus dark brown, slightly metallic; mesopleuron dark purple-brown with a coppery and brassy sheen, extreme posterior margin with a blue sheen; sides of propodeum metallic green; coxae dark brown with metallic green or blue reflections; femora concolorous but with distal apex of fore femur and apices of mid femora amber; femora pale amber, each with a basal dark brown ring, that on mid femur narrowest; fore tarsi dark brownish amber; mid and hind tarsi pale amber, pretarsi dark brown; wings hyaline, venation pale yellow-brown; gaster dark brown with a metallic green sheen, basal tergite more distinctly metallic green; visible part of gonostyli dark brown.

Frontovertex with shallow, fine, regular, reticulate sculpture and with shallow, but fairly conspicuous piliferous punctures each separated by a little more than their own diameters; between scrobes and eye margins and on genae, piliferous punctures indistinct and sculpture more longitudinally elongate; posterior ocelli slightly nearer eye than to occipital margin; occipital margin acute; eyes with very short setae, appearing virtually naked; antennal toruli separated from mouth margin by about their own lengths, with their mid-line about level with lowest eye margins; mandibles with two teeth and a truncation; pedicel plus flagellum about as long as head width or slightly shorter; other proportions of antenna as in Fig. 72. Relative measurements: HW 98; FV 32; POL 16; OOL 3.5; EL 56; EW 46; MS 28; SL 37; SW 10.

Mesoscutum with fairly regular, shallow, reticulate sculpture tending to imbricate-reticulate anteriorly and at sides; sculpture on scutellum similar but clearly longitudinally elongate and much shallower towards sides and apex; axillae almost smooth, with shallow imbricate sculpture; metapleuron and sides of propodeum clothed in conspicuous, pale, translucent setae, those on propodeum much longer; setation on base of forewing and venation as in Figs 73 and 74. Relative measurements: FWL 258, FWW 103; HWL 176, HWW 55.

Gaster at least nearly as long as thorax or longer and ovipositor slightly exerted, the exerted part at least half as long as mid tibial spur; hypopygium reaching to about two-thirds along gaster.

MALE. Unknown.

VARIATION. The paratype differs from the holotype in being much larger and the frontovertex has a distinct blue sheen with some purple reflections.

HOSTS. Unknown, but the holotype was collected with a *Calophya* sp. (see below).

DISTRIBUTION. Costa Rica.

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, Puntarenas, San Vito, Las

Cruces, Wilson Botanical Gardens, 1500m, swept with *Calophya* sp. B. Brown and Hodkinson (det. D. Hollis), 18–22.iii.1990 (J.S. Noyes). Paratype, **Costa Rica**, 1♀, San José, Zurqui de Moravia, 1600m, vii.1990 (P. Hanson). Holotype and paratype in BMNH.

COMMENTS. *Psyllaephagus tyche* can be separated from all other known New World species of the genus by the combination of the relatively slender antennae, blackish scape and slightly exserted ovipositor. The only other species known to us from this area with a similar combination of characters is *P. epulo* sp. nov. which has relatively smaller eyes, wider frontovertex and shorter gaster. In *epulo* the eyes do not quite reach the occipital margin, the frontovertex is very nearly half the head width and the gaster is about half as long as the thorax, whereas in *tyche* the eyes reach the occipital margin, the frontovertex is hardly more than half the head width and the gaster is at least nearly as long as the thorax.

Psyllaephagus trioziaphagus (Howard)

(Figs 3, 75–79, 143, 144)

Encyrtus trioziaphagus Howard, 1885: 14. Syntype ♀, USA, USNM, examined.

Psyllaephagus trioziaphagus (Howard); Ashmead, 1900: 383.

DIAGNOSIS. Female (length 0.95–1.52mm): coloration generally as in Fig. 3; head and dorsum of thorax metallic green, scutellum usually contrasting with a coppery or purple sheen; scape mostly dark brown or black, not paler than flagellum; tegulae brown; legs with all coxae and femora dark brown and tibiae generally yellow with narrow brown proximal bands or marks; ocelli forming an angle which varies from indistinctly acute to distinctly obtuse; antennae (Figs 76 and 77) with funicle segments widening distad, proximal segments generally slightly longer than broad, distal segments generally quadrate or slightly transverse; clava with a slight oblique apical truncation, the sutures oblique and converging ventrally; frontovertex varying from a little less than one-third to nearly half head width; mandibles as in Figs 143 and 144; scutellum relatively flat and with sculpture generally relatively shallow, shallower than that on mesoscutum; forewing venation as in Fig. 75; gaster about as long as thorax with hypopygium reaching to about three-quarters; third tergite medially with a characteristic lightly sclerotised area (see comments below); ovipositor (Fig. 78) varying from hidden to slightly exserted and about one-quarter to one-half longer than mid tibia. Male (length 0.76–1.17mm): similar to female but frontovertex less variable, about half head width, antennae (Fig. 79) and genitalia. Posterior ocelli about equidistant from eye and occipital margins; aedeagus about three-quarters as long as mid tibia.

VARIATION. As might be expected of a species with such a wide geographical range, the variation is quite marked in some characters of the female (see above), especially in the relative width of the frontovertex and ovipositor length. There is also slight variation in the shape of the proximal part of the second valvifer. Almost the complete range of variation in the female is found in material from varying localities in Costa Rica. In general, males are less variable, although some specimens have F1 only slightly longer than broad.

HOSTS. In the USA *P. trioziaphagus* has been recorded as a parasitoid of nymphs of *Trioza diospyri* (Ashmead) (Triozidae) (Howard, 1885). It is recorded below from Costa Rica as a solitary parasitoid of the nymphs of *Trioza* sp. near *maritima* (Triozidae) forming galls on the leaves of *Avicennia germinans* (Verbenaceae), and of *Mastigimas* sp. (Calophytidae, D. Hollis, pers. comm.) on *Cedrela odorata* (Meliaceae). It is recorded below also from Cuba as a parasitoid of *Mastigmas ernsti* (Schw.).

DISTRIBUTION. Brazil (Santa Catarina), Panama, Costa Rica, Cuba, USA and Canada.

MATERIAL EXAMINED.

Type material. Syntype ♀: 'N.533.a In Nov.8.81' 'Type No 2636 U.S.N.M.' 'Encyrtus trioziaphagus Howd. typ.' (USNM) (the specimen lacks the whole of one antenna and all but scape of other, and the apex of the gaster has been damaged, probably by Psocoptera). According to Howard the species was described from 4♀ and 2♂ reared from *Trioza diospyri* (Ashmead) in Washington, D.C., USA.

Non type material. **Canada**, 5♀, Alberta, Medicine Hat, 11.v.1980 (G.A.P. Gibson); **USA**, 1♀, Kentucky, Bernhei Forest, viii.1982 (M.G. Fitton, J. Quinlan); 2♀, 1♂, South Carolina, Clemson College, parasite of *Psylla* on persimon (C.O. Eddy); 5♀, 1♂, Texas, Brewster Co., Big Bend NP, 23–28.vi.1982 (G.A.P. Gibson); 1♀, Texas, Hidalgo Co., Santa Anna W. Refuge, 4.vii.1982 (G.A.P. Gibson); 1♀, 1♂, Texas, Cameron Co., Southpoint Nursery, 5–6.vii.1982 (G.A.P. Gibson); **Costa Rica**, 1♀, Guanacaste Prov., Santa Rosa NP, Sn. Emilio-6-c, 2–23.iii.1986 (D. Janzen, I.D. Gauld) (specimen compared with above syntype); 2♀, Guanacaste Prov., Guanacaste NP, EstMengo Vn Cacao, 1000m, v.1988 (I.D. Gauld, D. Janzen); 6♀, Guanacaste, Arenales, west side Volcan Cacao, 900m, 1988–1989 (no collector); 1♀, Guanacaste Prov., Guanacaste NP, below Est. Cacao, with *Trioza* sp., 3.iii.1990 (J.S. Noyes), 19♀, 20♂, Guanacaste Prov., Guanacaste NP, near Playa Naranja, 4 and 11.iii.1990; 1♀, 1♂, same data but ex psyllid gall, em. 14.iii.1990 (J.S. Noyes); 1♀, 3♂, same data but ex galls *Trioza* sp. nr *maritima* in leaves of *Avicennia germinans* (J.S. Noyes, J. Cox); 3♀, Guanacaste Prov., Guanacaste NP, Cacao, 950m, 13.ii.1995 (J.S. Noyes); 4♀, 1♂, San

Jose, San Pedro de Montes de Oca, 1100m, ex psyllid nymphs (*Mastigimas* sp.) on *Cedrela odorata*, iii.1991 (P. Hanson); 1♀, 1♂, Puntarenas, Gofito, with psyllids on mangrove, 20.iii.1990 (J.S. Noyes); **Mexico**, 1♀, Camp., 10Km W. Xpujil Chincanna, 300m, viii.1983 (M. Kaulbars); **Panama**, 1♀, Las Cumbres, 8–28.xii.1979 (H. Wolda); **Cuba**, 6♀, 9♂, Artemisa, ex *Coelocara ernsti* Schw., 14.x.1974 (A. Pintera); **Jamaica**, 2♀, 2♂, St Ann, Walkers Wood, 21.vii.1989, ex psyllid on indet. plant, 21.vii.1989 (H.W. Browning, F.D. Bennett); **Peru**, 1♀, Loreto, Iquitos, Quisto Coha, 5.ii.1984 (L. Huggert); **Brazil**, 13♀, 12♂, Santa Catarina, Nova Teuronia, vi.1943, xi.1949, xii.1949 (F. Plaumann); 1♀, Pelotas, ex psyllid, 8.iv.1963 (F.D. Bennett); 1♀, Sao Paulo, Teodora Sampaio, xii.1977 (M. Alvarenga); 2♀, 5♂, Sao Paulo, Aquas dos Pedro, ex psyllids on *Psidium guayava*, 24.i.1986 (F.D. Bennett); 3♀, 3♂, Mato Grosso do Sul, Vila Campestre, ex *Triozioidea* on guava, 22.ix.1985 (B. Löhr). Material in BMNH, INBio, CNC, UCR.

COMMENTS. We are unwilling to designate the above syntypic specimen as lectotype because of the remote possibility that other material exists in better condition. However, one specimen from Costa Rica (Santa Rosa NP, Santa Emilio 6-c, 2–23.iii.1986) compares with it very well and has been labelled as such. This specimen seems to match much better than those from USA and elsewhere, especially in the coloration of the thorax and the relative width of the frontovertex.

We have noted that females from all parts of the distribution of *trioziphagus* have a paler, more lightly sclerotised, median area on the third gastral tergite. This area appears to have a cluster of sensilla-like structures. The structure is unique within this genus in the New World but we have found it present in a number of European and African species. The presence or absence of this character does not seem to define any natural groups within *Psyllaephagus*.

The material treated here as *trioziphagus* may represent a complex of species, but we prefer to recognise only one until there is good evidence to support the acceptance of more. Even within Costa Rica there is some consistent variation between different populations. For instance, specimens from Playa Naranjo (mangrove swamp) have a relatively narrower frontovertex and ocelli forming a smaller angle than those only a few kilometres away at Cacao (950m) which have relatively shorter funicle segments and a wider frontovertex with ocelli forming a very obtuse angle. The greatest difference that we have observed is with material from Canada where the second valvifer of the ovipositor is clearly different in shape and the marginal vein of the hindwing is relatively more swollen than in material examined from elsewhere.

Psyllaephagus epulo sp. nov.

(Figs 80–82)

DIAGNOSIS. Female (length 1.28–1.37): head dull, with a copper, green and blue sheen; scape brown, not paler than flagellum; mesoscutum and scutellum metallic green with some coppery reflections; tegulae brown; femora dark brown; tibiae largely brown, yellowish towards apices; eyes relatively small and not quite reaching occipital margin; scape shorter than minimum width of frontovertex; ocelli forming an obtuse angle with posterior ocelli slightly closer to eyes than to occipital margin; frontovertex without conspicuous piliferous punctures; scutellum with deeper sculpture than mesoscutum; marginal vein hardly longer than broad; ovipositor hardly exerted. Male (length 1.76mm): face with a distinct change in sculpture and coloration level with antennal toruli, above this sculpture distinctly finer and rougher and coloration purplish in contrast with smoother sculpture and green coloration; scape and flagellum concolorous blackish; antennae with F1 more than twice as long as broad; scutellum with sculpture mostly deeper than that on mesoscutum.

FEMALE (HOLOTYPE). Length 1.37mm. Head on frontovertex dark metallic green, blue-green along inner eye margins; level with antennal scrobes purplish, interantennal prominence largely purple; lower parts of face and clypeal margin bluish; temples purplish; postocellar area with some coppery purple reflections; antennae dark brown, scape and pedicel almost black with a slight metallic sheen; mesoscutum green with small coppery areas; scutellum green, but extensively coppery in basal half or so; axillae dark coppery purple-brown; tegulae dark brown; sides of pronotum and prepectus brown with a metallic green sheen; mesopleuron similar but brighter and slightly brassy; metapleuron and sides of propodeum metallic blue-green; coxae dark brown with slight purple and green reflections; femora concolorous but marked with yellowish at apices; fore tibiae and hind tibia mostly dark brown with distal apex yellowish; mid tibia brown in basal half, apical half yellowish; mid and hind tarsi yellow-brown, darker apically; mid tarsi pale yellow basally gradually darkening to dark brown pretarsi; mid tibial spur yellow; wings hyaline, venation dark yellow-brown; gaster dark brown with metallic purple and green sheen, basal tergite distinctly metallic blue-green mixed with some purple; visible part of gonostyli dark brown.

Frontovertex with conspicuous, regular, fine hexagonally reticulate sculpture of granular appearance; piliferous punctures inconspicuous; sculpture between scrobes and eyes slightly irregular and shallower and longitudinally elongate; sculpture on genae conspicuously shallower and smoother; antennal toruli

separated from mouth margin by about $1.3 \times$ their own lengths; posterior ocelli slightly nearer occipital margin than eye margin; occipital margin conspicuously rounded; eyes with sparse, very short setae, appearing virtually naked; mandibles with two teeth and a truncation; pedicel and flagellum together very slightly longer than head width; other proportions of antenna as in Fig. 80. Relative measurements: HW 93; FV 44; POL 26; OOL 4.5; EL 47; EW 36; MS 32; SL 33; SW 8.

Mesoscutum with fine, raised, more or less regular reticulate sculpture, this tending towards imbricate-reticulate laterally, sculpture slightly deeper than sculpture on frontovertex; scutellum with clearly deeper, longitudinally elongate reticulate sculpture, extreme sides posteriorly, and apex smooth and shiny; axillae almost smooth; metapleuron and sides of propodeum clothed in relatively sparse, fairly conspicuous, translucent setae; setation on base of forewing and venation as in Figs 81 and 82. Relative measurements: FWL 231, FWW 104; HWL 159, HWW 51.

Gaster about half as long as thorax with ovipositor hardly exerted, the exerted part about one-third as long as mid tibial spur; hypopygium reaching about half way along gaster.

MALE. Length 1.76mm. Similar to female but head with an abrupt change in sculpture and coloration level with middle of antennal toruli, above this sculpture relatively finely reticulate and below this conspicuously smoother, less regular, reticulate sculpture of larger mesh; above this line purplish changing to blue green in the ocellar area, area below green with some brassy and blue reflections. Antenna similar to that of *P. othrys* (Fig. 52) but with F1 and F2 more slender and longer than broad; genitalia with aedeagus about two-thirds as long as mid tibia. Relative measurements: HW 98; FV 52; POL 29; OOL 6; EL 42; EW 33; MS 36; SL 25; SW 11.

VARIATION. Very little other than colour in material examined. The paratype female is generally slightly darker than the holotype with the paler parts of the legs being slightly dusky yellow and the scutellum having a slightly bluish sheen.

HOSTS. Reared from galls formed by *Trioza* sp. *magnoliae* group (det. D. Hollis) on the fruit of *Cinnamomum hammelianum* (see below as *cinnamomifolia* misidentification).

DISTRIBUTION. Costa Rica, montane habitats.

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, Alajuela, P.N. Volcan Poas, psyllid gall on Magnoliaceae, 2500m, 25.x.1990 (P. Hanson). Paratypes: **Costa Rica**, 2♀, 1♂, Alajuela, Volcan Poas, 2,400m, ex triozid galls on fruit of *Phoebe cinnamomifolia*, i/ii.1995 (P. Hanson).

Holotype and paratypes in BMNH, paratype in INBio.

COMMENTS. Although significantly different in habitus, *P. epulo* has many characters in common with *P. tyche* but can be separated principally on the smaller eyes and shorter gaster (see comments under *tyche* above).

Psyllaphagus thonis sp. nov.

(Figs 83–85)

DIAGNOSIS. Female (length 1.68mm): scape brown, not paler than flagellum; tegulae brown; head and mesoscutum with only a very feeble metallic sheen; scutellum distinctly more metallic coppery and bluish; femora dark brown; tibiae yellow with bases inconspicuously marked with brown; marginal vein punctiform; ocelli forming an obtuse angle and with posterior ocelli about equidistant from eye and occipital margin; frontovertex without conspicuous piliferous punctures; scape shorter than minimum width of frontovertex; scutellum with deeper sculpture than mesoscutum; ovipositor not exerted.

FEMALE (HOLOTYPE). Head on frontovertex dull, dark metallic green with ocellar area slightly purplish; metallic green below antennal toruli but mouth margin distinctly purplish; scape dark brown, slightly metallic, its apex yellowish; pedicel similarly coloured to scape; flagellum brown; mesoscutum predominantly dull metallic green but with brassy, coppery and purple reflections; scutellum similar but brighter green and with sides blue; axillae coppery purple; tegulae dark brown; sides of thorax dark purple-brown; sides of propodeum metallic blue-green; coxae dark brown with slight purple, blue and brassy reflections; femora concolorous but marked with yellowish at apices; tibiae mostly yellow but with faint brown bands in basal one-third; tarsi yellow, pretarsi brown; wings hyaline, venation yellow-brown; gaster dark brown with metallic purple and green sheen, basal tergite distinctly metallic blue-green mixed with some purple; visible part of gonostyli dark brown, but apically yellowish.

Frontovertex with coarse, irregular, raised, reticulate sculpture which is almost granular in appearance; between eyes and scrobes sculpture less coarse and more regular; scrobal area, mouth margin and other areas with shallower sculpture and more shiny; antennal toruli separated from mouth margin by slightly more than their own lengths; posterior ocelli about equidistant from eye and occipital margins; eyes with very short, but fairly conspicuous, setae; mandibles with one tooth and a broad truncation; pedicel and flagellum together about as long as head width; sensory area of clava longer than the combined ventral lengths of its first two segments; other proportions of antenna as in Fig. 83. Relative meas-

urements: HW 103; FV 44; POL 25; OOL 4; EL 57; EW 45; MS 33; SL 38; SW 8.

Mesoscutum with similar sculpture to frontovertex but less coarse and more regular; scutellum with slightly deeper, longitudinally reticulate sculpture, extreme sides posteriorly, and apex with very shallow sculpture, almost smooth and shiny; axillae with shallow, reticulate sculpture; metapleuron and sides of propodeum clothed in relatively conspicuous, silvery, translucent setae; setation on base of forewing and venation as in Figs 84 and 85. Relative measurements: FWL 220, FWW 96; HWL 147, HWW 47.

Gaster slightly shorter than thorax with ovipositor not exerted; hypopygium reaching about three-quarters along gaster.

MALE. Unknown.

HOSTS. Unknown.

DISTRIBUTION. Costa Rica.

MATERIAL EXAMINED.

Holotype ♀, **Costa Rica**, San Jose, Ciudad Colon, 800m, ii.1990 (L. Fournier). In BMNH.

COMMENTS. *P. thonis* is very close to *alexion* (see comments under *alexion* and *ufens*).

Psyllaephagus alexion sp. nov.

(Figs 86–89, 145)

DIAGNOSIS. Female (length 1.48–1.51mm): head black slightly shiny, mesoscutum similar but with a slightly metallic green lustre, scutellum more shiny, metallic green, slightly coppery; scape brown, not paler than flagellum; tegulae brown; femora dark brown; tibiae yellow with a faint brown spot basally; frontovertex without conspicuous piliferous punctures; ocelli forming an obtuse angle; scape shorter than minimum width of frontovertex; scutellum with deeper sculpture than mesoscutum, the sculpture finely reticulate but not arranged in whorls or longitudinal lines; marginal vein punctiform; ovipositor not exerted.

FEMALE (HOLOTYPE). Length 1.51mm. Head on frontovertex dull, dark metallic green with ocellar area slightly purplish; metallic green below antennal toruli but mouth margin distinctly purplish; scape dark brown, slightly metallic, its apex yellowish; pedicel similarly coloured to scape; flagellum testaceous-brown; mesoscutum predominantly dull metallic green but with brassy, coppery and purple reflections; scutellum similar but brighter green and with a slight coppery sheen; axillae coppery purple; tegulae dark brown; sides of thorax dark purple-brown; sides of propodeum metallic blue-green; coxae dark brown with slight purple, blue and brassy reflections; femora concolorous but

marked with yellowish at apices; tibiae mostly yellow but with faint brown bands in basal one-third; tarsi yellow, pretarsi brown; wings hyaline, venation yellow-brown; gaster dark brown with metallic purple and green sheen, basal tergite distinctly metallic blue-green mixed with some purple; visible part of gonostyli dark brown.

Frontovertex with coarse, irregular, raised, reticulate sculpture which is almost granular in appearance in ocellar area; between eyes and scrobes sculpture less coarse and more regular; scrobal area, mouth margin and other areas with shallower sculpture and more shiny; antennal toruli separated from mouth margin by slightly more than their own lengths; mandible as in Fig. 145; posterior ocelli about equidistant from eye and occipital margins; eyes with very short, but fairly conspicuous, setae; mandibles with one tooth and a broad truncation; pedicel and flagellum together about as long as head width; clava with apical sensory area shorter than ventral surfaces of proximal two segments combined; other proportions of antenna as in Fig. 86. Relative measurements: HW 80; FV 30; POL 15.5; OOL 3; OCL 3.5; EL 48; EW 37; MS 23; SL 30; SW 7.

Mesoscutum with shallow imbricate-reticulate sculpture tending to polygonally reticulate towards posterior margin; scutellum with conspicuously deeper, finely reticulate sculpture, this not arranged in conspicuous lines or whorls, although laterally each cell elongate, extreme sides posteriorly, and apex with very shallow sculpture, almost smooth and shiny; axillae with shallow, reticulate sculpture; metapleuron and sides of propodeum clothed in relatively conspicuous, silvery, translucent setae; setation on base of forewing and venation as in Figs 87 and 88. Relative measurements: FWL 178, FWW 74; HWL 118, HWW 35.

Gaster slightly shorter than thorax with ovipositor not exerted; hypopygium, in critical-point-dried holotype, nearly reaching apex of gaster; ovipositor (Fig. 89) a little longer than mid tibia. Relative measurements (paratype): OL 61, GL 12 [MT 50].

MALE. Unknown.

HOSTS. Unknown.

DISTRIBUTION. Costa Rica.

MATERIAL EXAMINED.

Holotype♀, **Costa Rica**, Puntarenas, R.F. Golfo Dulce, 24 Km W. Piedras Blancas, 200m, 11.v.1991 (P. Hanson). Paratype, **Costa Rica**, 1♀, Alajuela, Peñas Blancas, 23.v.1987 (E. Cruz). Material in BMNH.

COMMENTS. *P. alexion* is similar to *ufens* and *thonis* (see comments under *ufens*) and can be separated from *ufens* on the colour of the scape (see key). Initially *alexion* and *thonis* were thought to represent varieties

of a single species but the relative length of the sensory part of the clava along with other minor differences indicates that the two should be treated as separate species. In *alexion* the sensory part of the clava is shorter than the combined ventral lengths of its first two segments, the ocelli form an angle of about 90°, and the sculpture of the frontovertex below the anterior ocellus and on the mesoscutum is relatively shallower. In *thonis* the sensory part of the clava is longer the combined ventral lengths of its first two segments, the ocelli form a distinctly obtuse angle, and the sculpture of the frontovertex below the anterior ocellus and on the mesoscutum is relatively coarse.

There is also some similarity between *P. alexion* and *P. baccharidis* Tavares and Perito described from southern Brazil. Both species have a similar habitus and leg coloration. *P. baccharidis* differs in being generally brighter in coloration, the head and dorsum of thorax being bright metallic green whereas in *alexion* these parts are relatively dull. Also in *baccharidis*, the scutellum is similar in coloration and sculpture to the mesoscutum whilst in *alexion* the scutellum is significantly brighter and with deeper sculpture than the mesoscutum. The frontovertex of *baccharidis* also has no distinct piliferous punctures and the posterior ocelli are clearly closer to the eye margin than occipital margin, whilst in *alexion* the frontovertex has shallow, but conspicuous piliferous punctures and the posterior ocelli are about equidistant from the eye and occipital margins.

Psyllaephagus rotundiformis (Howard)

(Figs 90–94)

Encyrtus rotundiformis Howard, 1897: 154. Lectotype designated by Noyes (1979), Grenada, USNM, examined.

Psyllaephagus rotundiformis (Howard); Noyes, 1979: 165.

DIAGNOSIS. Female (length 0.95–1.27mm): tegulae brown; mesoscutum bright metallic green, more shiny than scutellum; femora dark brown; mid tibia yellow without a distinct subbasal ring; hind tibia yellow with dark brown area extending only about half way; frontovertex without conspicuous piliferous punctures; marginal vein more or less punctiform. Females: scape brown, not paler than flagellum; ocelli forming an obtuse angle; pedicel and flagellum together longer than head width. scape shorter than minimum width of frontovertex; scutellum with coarsely reticulate sculpture which is deeper than sculpture on mesoscutum and arranged in whorls or longitudinal lines; ovipositor not exerted. Male (length 0.79–1.19mm): posterior ocelli about equidistant from occipital and eye margins; F6 more than 1.35 × as long as broad; basal cell of forewing with more than 50 setae.

FEMALE. Frontovertex metallic green or blue-green,

scrobal area purple, mouth margin blue; scape dark brown with apical one-quarter yellow; pedicel dark brown with apex yellow; flagellum pale yellow-brown; mesoscutum bright metallic green; scutellum metallic green, but distinctly coppery in basal half; tegulae dark brown; sides of thorax dark brown, but mesopleuron with a weak metallic brassy green sheen; sides of propodeum metallic green; wings hyaline, venation pale testaceous-brown; all coxae dark brown; femora dark brown with apices yellow; fore and mid tibia with a faint, narrow subbasal ring; hind tibia yellow with basal half almost entirely brown; gaster dark purple brown with a metallic green sheen, basal tergite strongly metallic green; visible part of gonostyli dark brown.

Frontovertex shiny with regular, very shallow, reticulate sculpture which is interspersed with shallow piliferous punctures giving the sculpture an irregular appearance; lower parts of head somewhat duller and with irregular, elongate sculpture, especially on genae; eyes with very sparse setae, appearing almost naked; antennal toruli separated from mouth margin by slightly less than their own lengths and with their dorsal margins hardly below ventral eye margins; mandibles with one tooth and a broad truncation; frontovertex about one-third to two-fifths head width; scape about as long as frontovertex width; antennae (Fig. 90) with pedicel and flagellum together longer than head width, proximal funicle segments generally longer than broad and distal ones subquadrate.

Mesoscutum with shallow, regular imbricate-reticulate sculpture; scutellum with conspicuously deeper, longitudinally striate-reticulate sculpture, sides and apex very shiny, almost smooth; venation and setation at base of forewing as in Figs 91 and 92, the setation on the dorsal surface of the costal cell extending at least two-thirds the way towards base and dorsal surface of basal cell with at least 60 setae.

Gaster about as long as thorax; hypopygium reaching to about four-fifths along gaster; ovipositor not exerted, or hardly so, the exerted part not more than one-third as long as mid tibial spur; ovipositor (Fig. 93) nearly one-third longer than mid tibia.

MALE. Generally similar to female except colour and structure of antenna (Fig. 94), colour of face, width of frontovertex and structure of genitalia. Face shining metallic green; scape pale yellow with a dark brown spot dorsally in basal half; flagellum pale testaceous-brown; F6 at least 1.35 × as long as broad; dorsal surface of basal cell with at least 50 setae.

HOSTS. Unknown.

DISTRIBUTION. Jamaica, Grenada, St Vincent, Tobago, Trinidad, Belize, Costa Rica, Panama, Peru, Brazil.

MATERIAL EXAMINED.

Type material. Lectotype ♀, **Grenada**, windward side, Mirabeau Est., H.H. Smith, '*Encyrtus rotundiformis* How. ♀', parts on slide labelled '*Encyrtus rotundiformis* How. ♀ type' (USNM). Paralectotype, **Grenada**, 1♀, windward side, Balthazar (H.H. Smith) (right forewing and gaster only) (BMNH).

Non type material. **Jamaica**, 3♂, Portland, Port Antonio, Bonnie view pool, 2–7.vii.1982 (N.F. & J.B. Johnson); **St Vincent**, 3♀, 7♂, various localities, 8–12.vii.1976 (J.S. Noyes); **Tobago**, 5♀, 6♂, various localities, 20–23.vii.1976 (J.S. Noyes); **Trinidad** 16♀, 29♂, various localities, 16.vi–9.viii.1976 (J.S. Noyes); **Belize**, 3♀, 5♂, Airport Camp, swamp, ii.1982 (M. Grimshaw); 1♀, Punta Gorda, 12–26.v.1982 (P. Kelly); **Costa Rica**, 1♀, Guanacaste, sw side of Volcan Cacao, Estac. Cacao, 1100m, 1988–1989; 2♀, Alajuela, Chiles de Aguas, Zarcas café, xii.1989 (R. Céspedes; P. Hanson); 1♀, San Jose, Ciudad Colon, 800m, ii.1990 (L. Fournier); 1♀, 3♂, Limon, RB Hitoy-Cerere, 100m, 14–19.i.1991 (J.S. Noyes); **Panama**, ♀, Las Cumbres, 8–22.xii.1979 (H. Wolda); **Peru**, 7♂, Junin, Satipo, 18–19.i.1984 (L. Huggert); **Brazil**, 1♀, Rio de Janeiro, Conceiaco de Macabu, xi.1978 (M. Alvarenga). Material in BMNH, INBio, CNC, UCR.

COMMENTS. *P. rotundiformis* is very close to *yaseeni* but differs in antennal structure, colour of tibiae, and setation of basal and costal cells of forewing (see key and diagnosis for *yaseeni*).

Psyllaephagus yaseeni Noyes

(Figs 95–99)

Psyllaephagus sp. nr. *rotundiformis* (Howard); Murai, 1986: 1–6.

Psyllaephagus yaseeni Noyes, 1990: 39–40. Holotype ♀, Hawaii, BMNH, examined.

DIAGNOSIS. This species is very close to *rotundiformis* but differs as follows. Female (length 0.79–1.24mm): mid tibia with a well-marked, conspicuous, dark brown basal ring; hind tibia with at least proximal three-quarters dark brown; forewing venation dark brown; mandible as in Fig. 146; antenna (Fig. 96) with pedicel and flagellum shorter than head width; forewing (Fig. 97 and 98) with not more than 50 setae on dorsal surface of basal cell and with setae on dorsal surface of costal cell not extending more than half way towards base, or hardly so; ovipositor as in Fig. 99. Male (length 0.68–0.94mm): antenna (Fig. 95) with F6 not more than 1.25 × as long as broad; forewing with not more than 40 setae in dorsal surface of basal cell; otherwise similar to female.

HOSTS. *Psyllaephagus yaseeni* is a solitary, internal parasitoid of first and second instar nymphs of *Heteropsylla cubana* (Murai, 1986). Parasitised nymphs continue to feed until the fifth instar when

they become mummified and turn brown. The adult parasitoid emerges eight or nine days later. *P. yaseeni* has also been reared from an unidentified species of *Heteropsylla* on *Mimosa invisa* (Noyes, 1990), but in host specificity tests it did not attack *Heteropsylla huasachae* Caldwell and *H. fusca* Crawford (Murai, 1986), although the species has been collected with *H. curta* Muddiman, Hodkinson & Hollis in Jamaica (see below). The parasitoid has also been reared from an unidentified psyllid on *Cojoba arborea* (see below).

USE IN BIOCONTROL. *P. yaseeni* has been introduced into a number of countries in attempts to control *Heteropsylla cubana* Crawford, a pest of *Leucaena leucocephala* (see Noyes & Hayat, 1984; IIBC, 1993). This plant is used commonly in these countries as cattle fodder, green manure, shade plant for coffee and cocoa and as a nitrogen fixing plant in alley cropping. It has become established in at least some of these countries, and is at least partially responsible for effective control of the psyllid (IIBC, 1994).

DISTRIBUTION. USA (Texas and Florida), Mexico, Cuba, Haiti, Jamaica, Puerto Rico, Tobago, Anguilla, Costa Rica, Colombia and introduced into Hawaii, New Caledonia, China (Hainan), Philippines, Malaysia, Thailand, Nepal and Sri Lanka.

MATERIAL EXAMINED.

Type material. Holotype ♀, **Hawaii**, Oahu, Manoa, ex *Heteropsylla cubana* nymphs on *Leucaena leucocephala* l.xi.1988 (G.Y. Funasaki) (BMNH). Paratypes, 68♀, 33♂, from **Hawaii, Mexico, Cuba, Haiti, Jamaica, Tobago** and **Colombia** (see Noyes, 1990 for a full list and depositories).

Non type material. **USA**, 7♀, 1♂, Texas, Brewster Co., Big Bend NP, 23–28.vi.1982, 9–16.vii.1982, (G.A. P. Gibson); 1♂, Texas, Jeff Davis Co., Davis Mts. St. Pk., 5000' (=1527m), 17–18.vii.1982 (G.A.P. Gibson); 2♀, Texas, Culberson Co., Guadalupe Springs, 5200' (=1588m), 20–22.vii.1982 (G.A.P. Gibson); 3♀, 1♂, Florida, Big Pine Key, ex nymph *Heteropsylla cubana* on *Leucaena leucocephala*, 25.vi.1990 (F.D. Bennett); **Mexico**, 1♂, Nuevo Leon, Limares, Bachimba, Km 14, 7.vii.1984 (M.A. Rodriguez); 1♀, Nuevo Leon, Limares, Huerta San Jorge, Km 62, 7.vii.1984 (M.A. Rodriguez); 1♀, Oaxaca, Pto. Escondida, of *Leucaena leucocephala* inf. with psyllids, 3.xi.1988; 1♀, Acapulco, Pic de la Cuesta, of *Leucaena leucocephala*, 15.xi.1988; 2♀, Oaxaca, Rincon Bamba, in flower of *Leucaena* sp., 12.xi.1988; **Jamaica**, 9♂, Irishtown, with *Heteropsylla curta* on *Acacia sillosa* (misidentified as *Heteropsylla huasachae* on ?*Leucaena leucocephala*, D. Hollis, pers. comm.) 10.vii.1988 (D. Hollis); **Puerto Rico**, 4♀, 1♂, Isabela, ex *Heteropsylla cubana* on *L. leucocephala*, 19.xi.1988 (F.D. Bennett); **Anguila**, 11♀, 1♂, various 12.ii–

7.vii.1982 (A.G. Parker); **St Lucia**, 1♂, 1982 (C. Bolter); **Costa Rica**, 4♀, San José, Univ. Campus, 27.ii.1990 (J.S. Noyes); 1♀, San José, San Pedro de Monte de Oca, 1100m, ex psyllid on *Pithecellobium arboreum* (= *Cajoba arborea*), iv.1990 (P. Hanson); 1♂, Puntarenas, Monteverde, 15–16.vii.1986 (L. Masner); 1♀, Puntarenas, Pen Osa, Puerto Jimenez, 10m, iv.1991 (P. Hanson); **Colombia**, Caldas Rio Sucio, ex legume assoc. with Psyllidae, 10.vii.1990 (G. Garcia); **Philippines**, 1♀, *L. leucocephala*, NCPL, 3.iii.1990 (L.B. Flor). Material in BMNH, INBio, UCR.

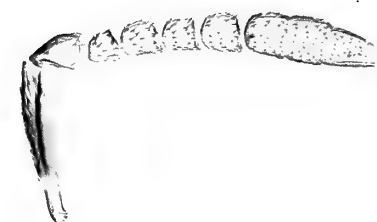
COMMENTS. *P. yaseeni* is very close to *rotundiformis* but differs in antennal structure, colour of tibiae, and setation of basal and costal cells of forewing (see key and above diagnosis).

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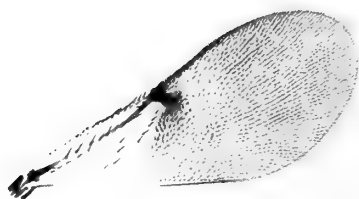
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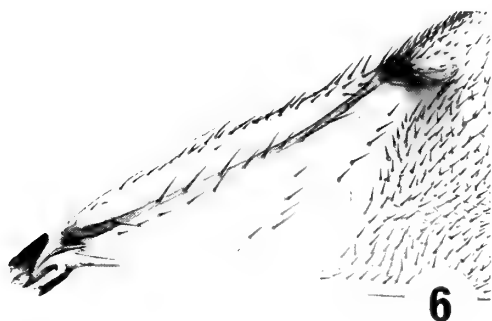
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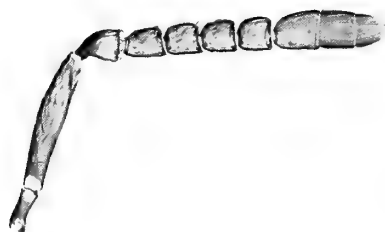
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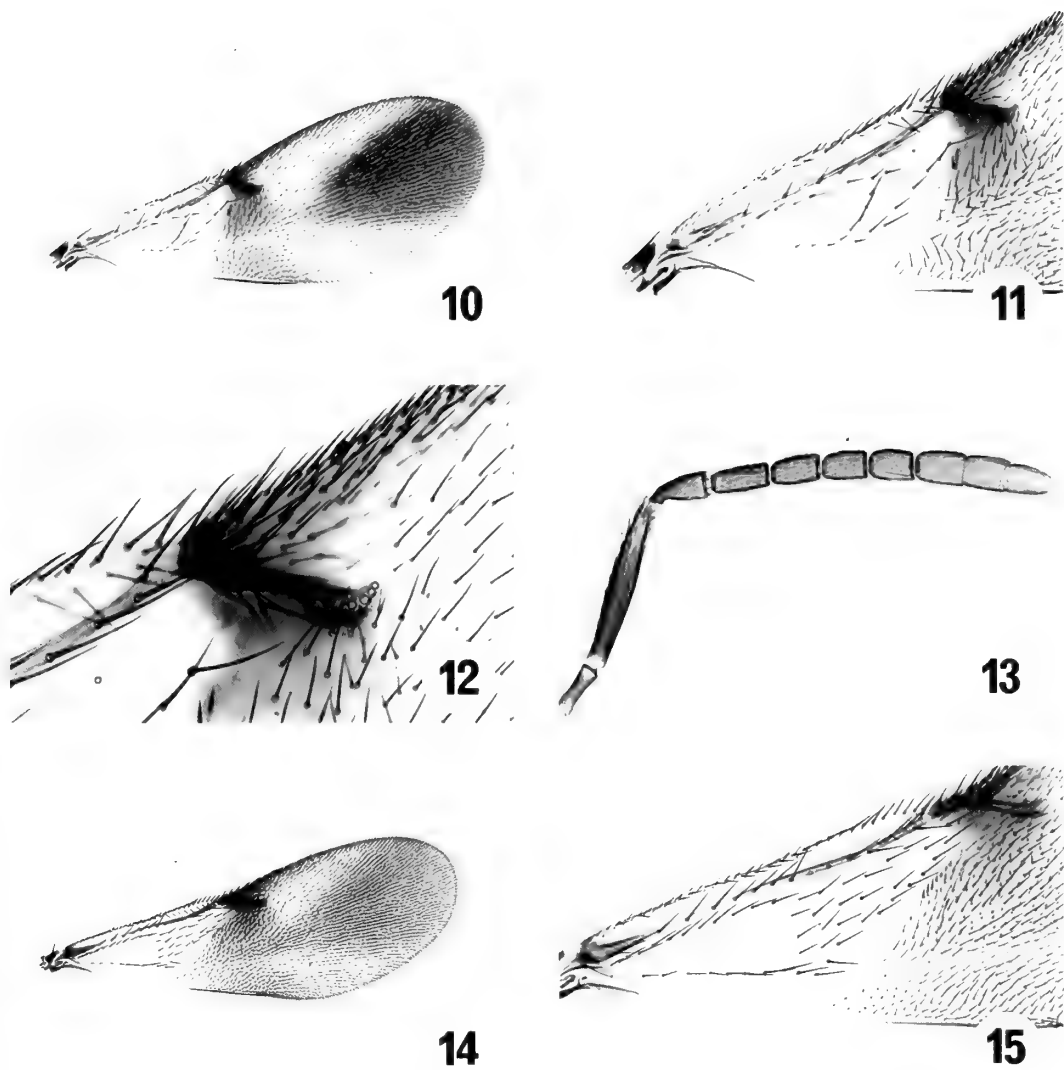


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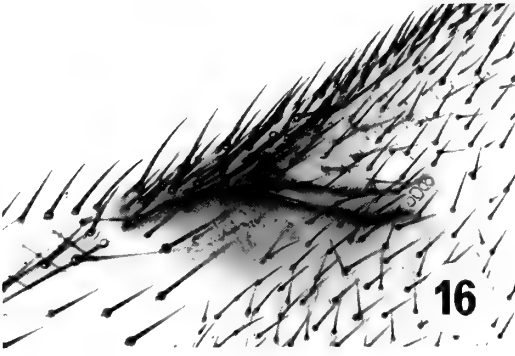


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Figs 4–9 *Cercobelus isara* – 4, antenna, ♀; 5, forewing ♀; 6, forewing base, ♀; 7, apex of forewing venation, ♀; 8, antenna, ♂; *Cercobelus sithon* – 9, antenna, ♀.



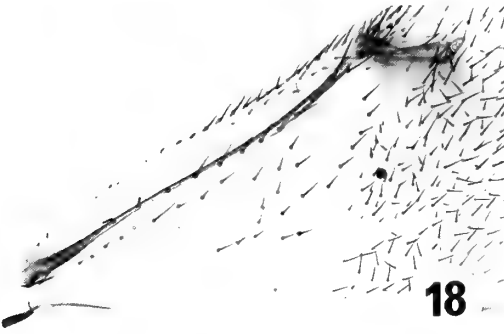
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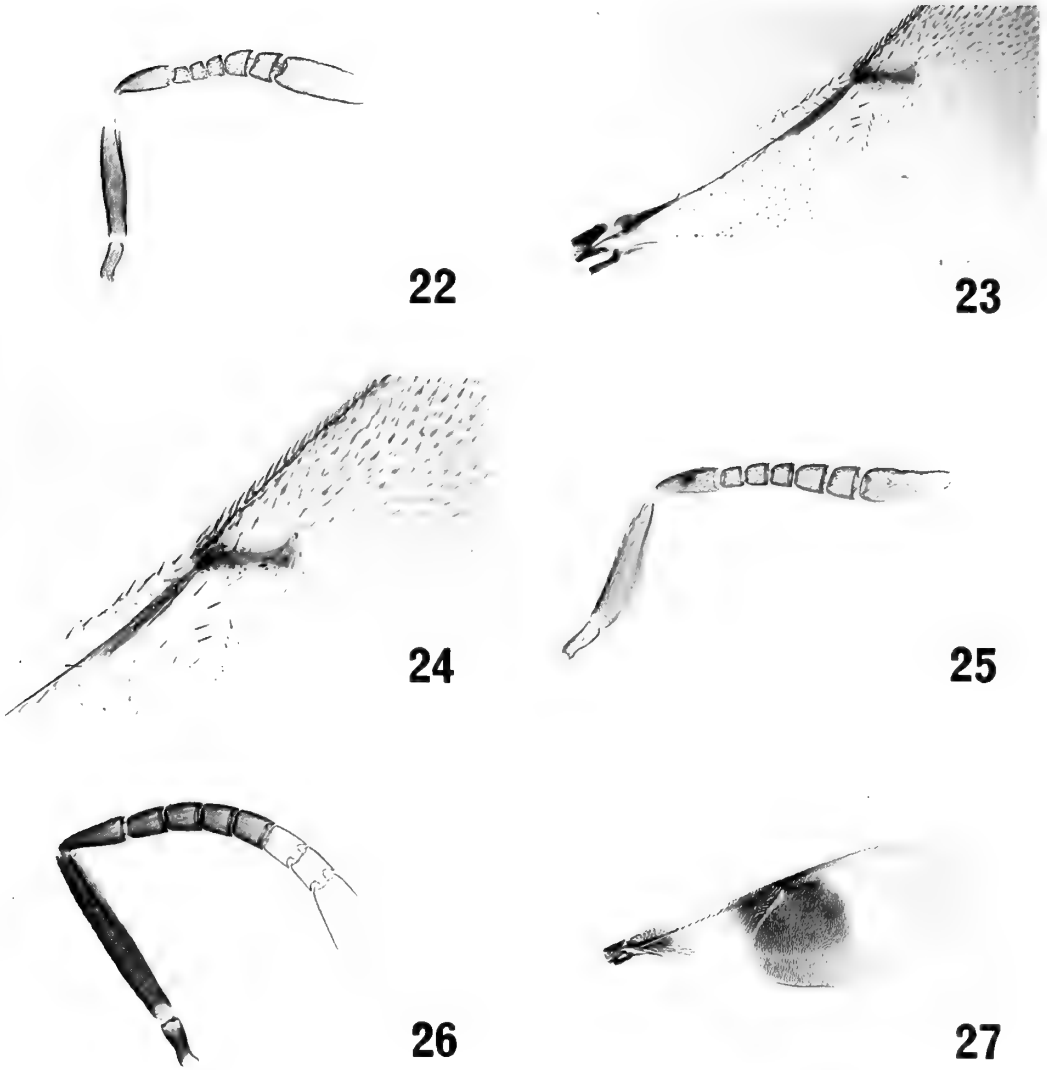


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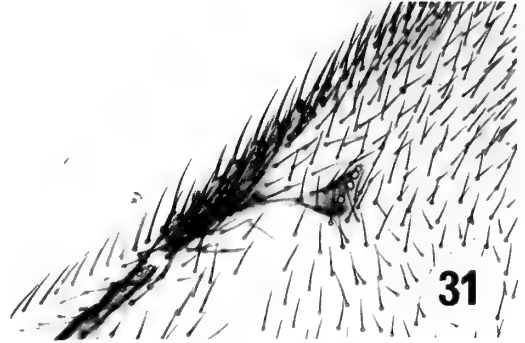
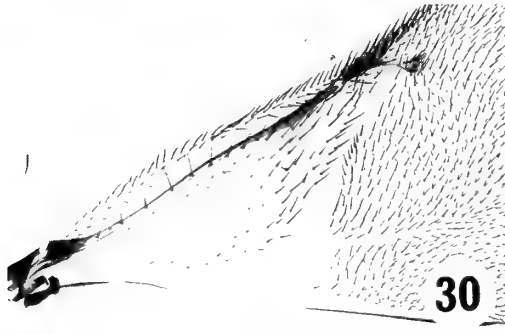
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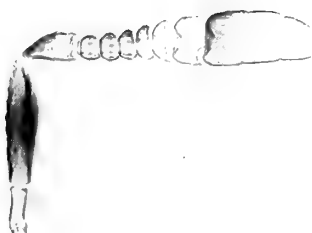


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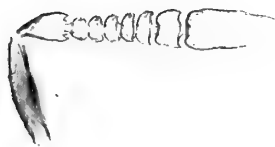
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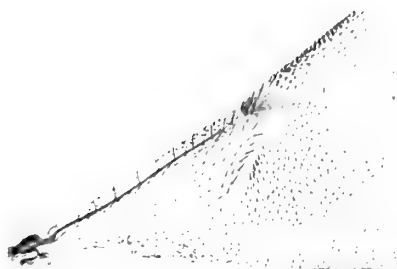
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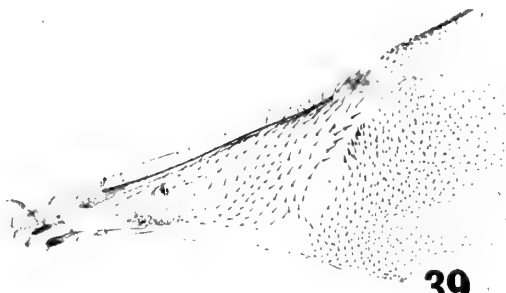
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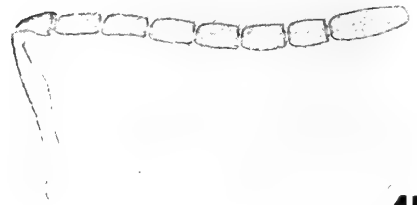
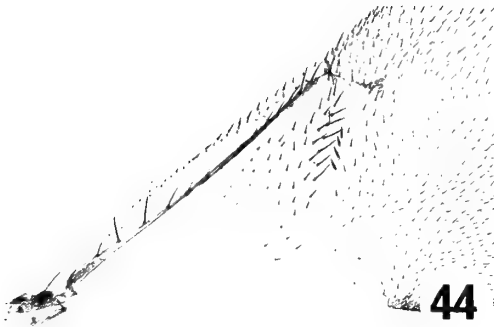
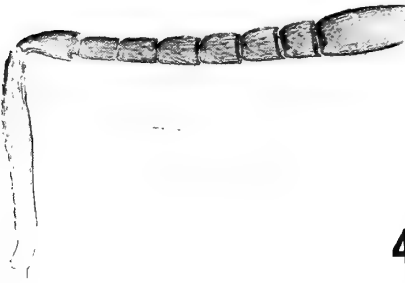
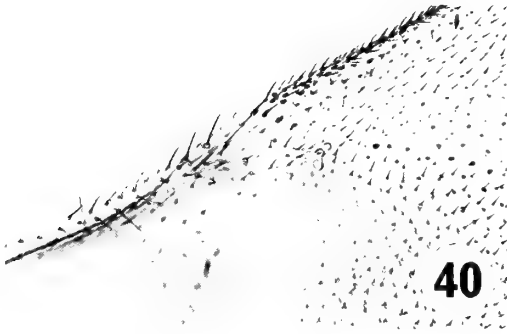


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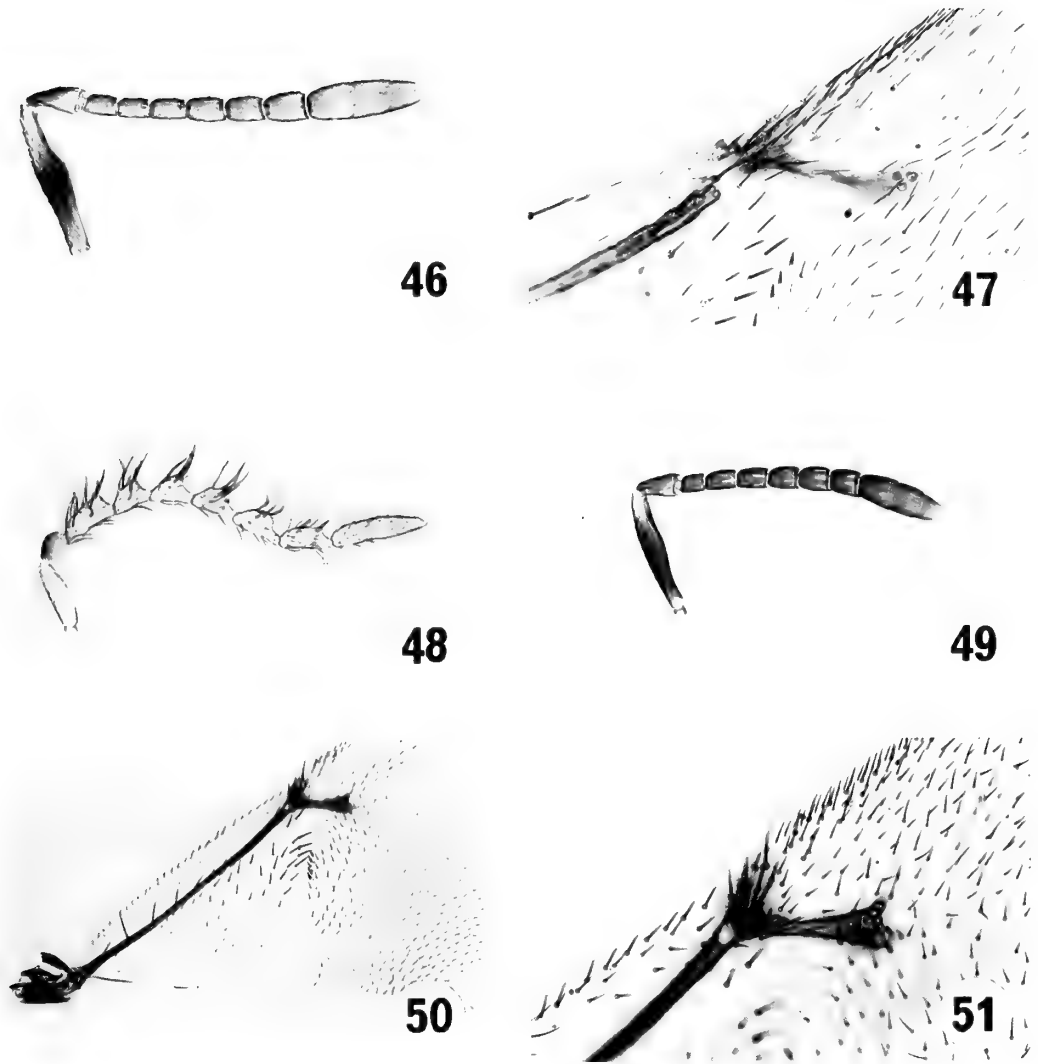


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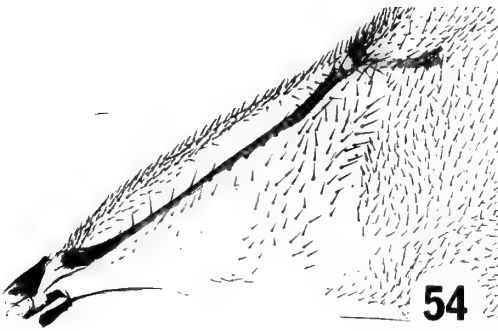
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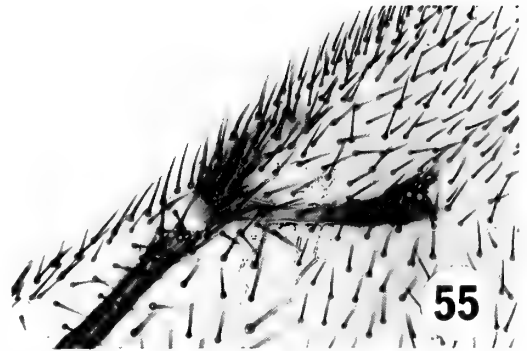
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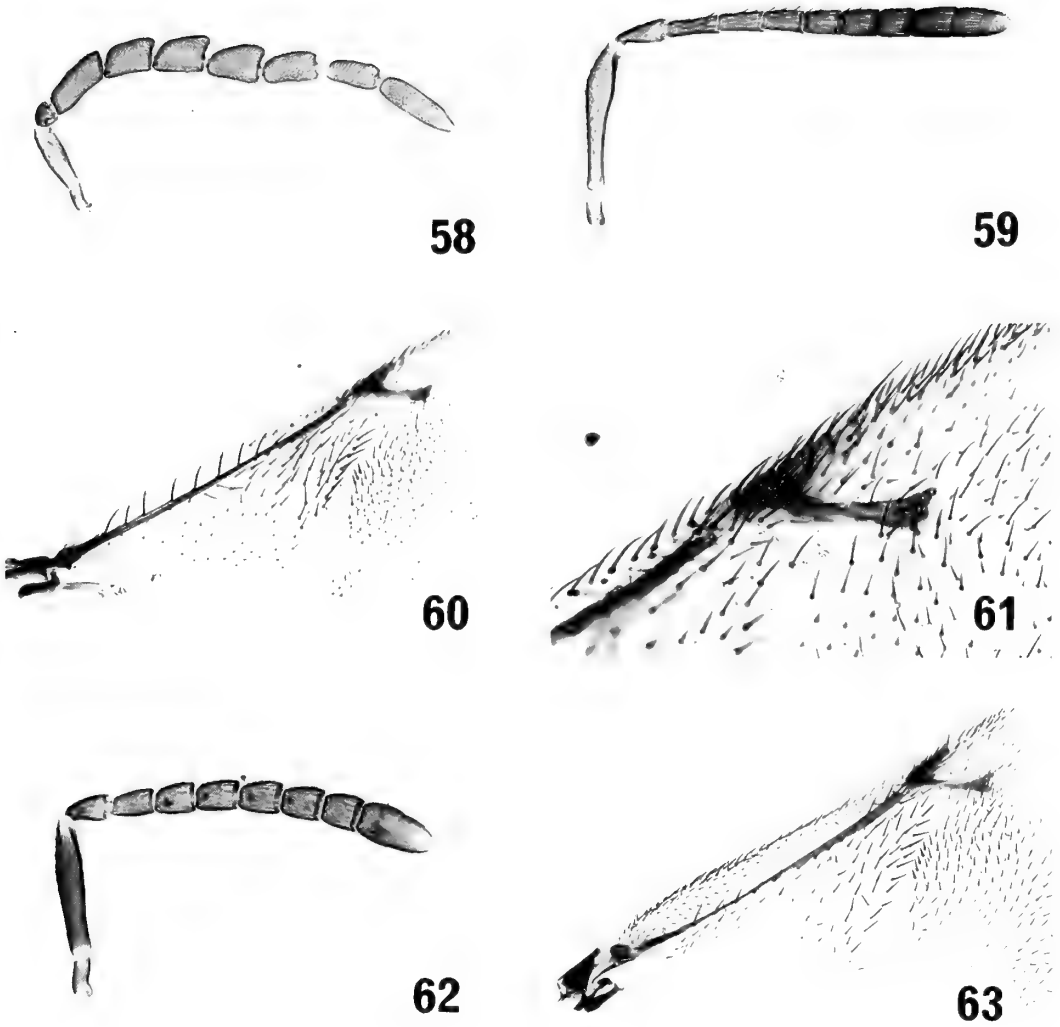


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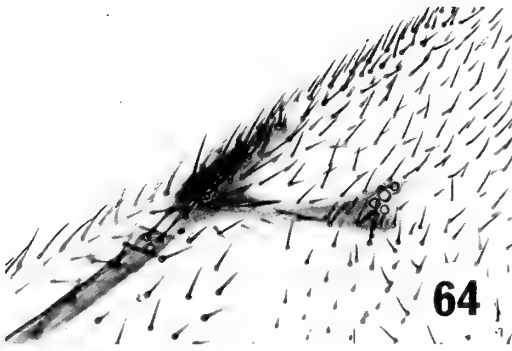


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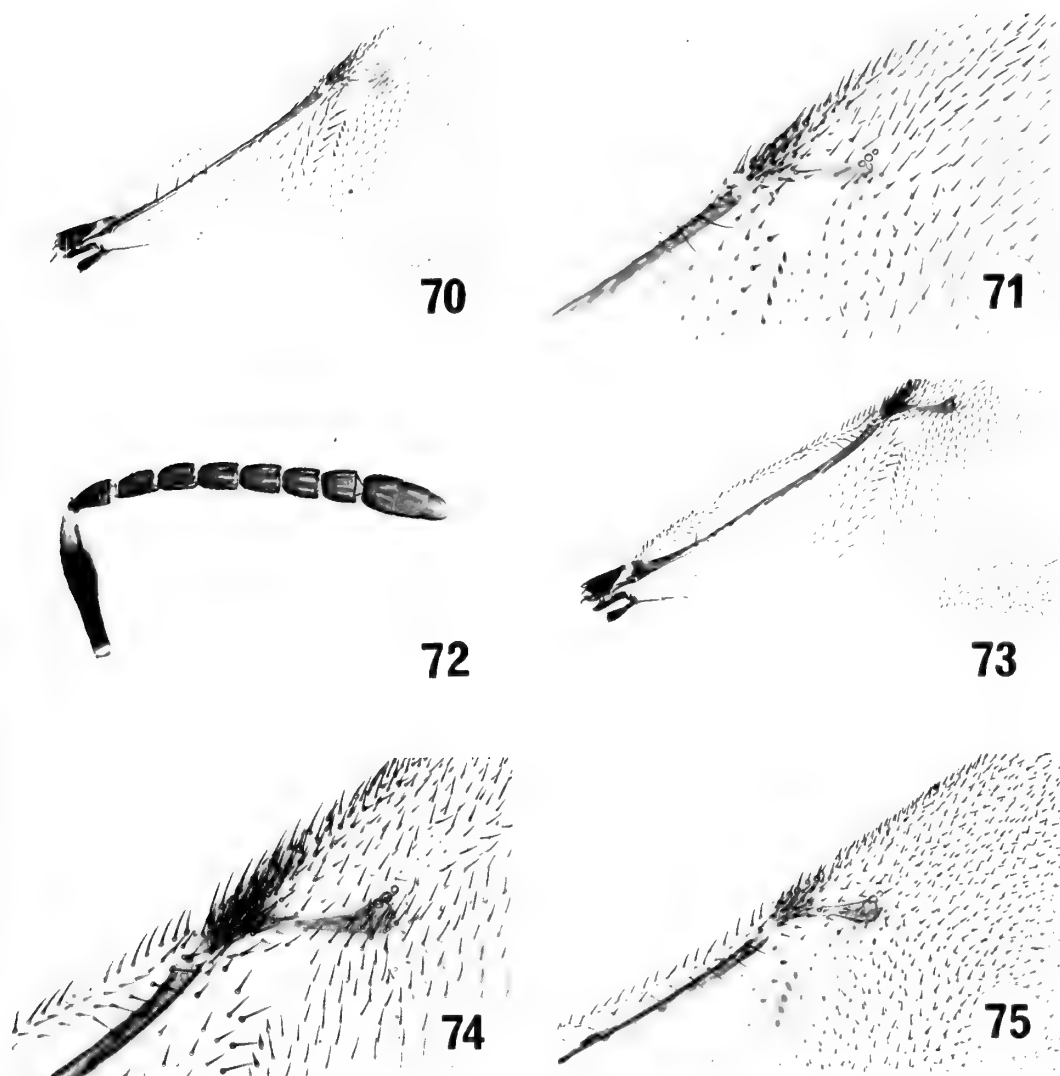


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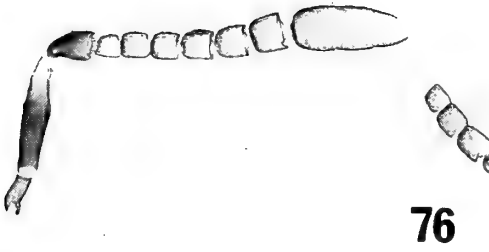


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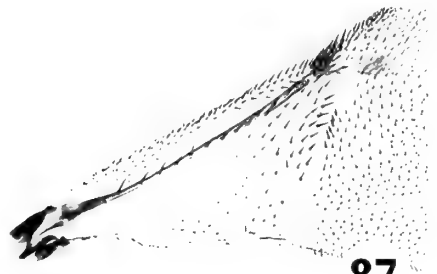
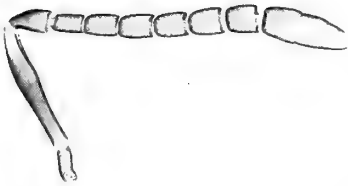
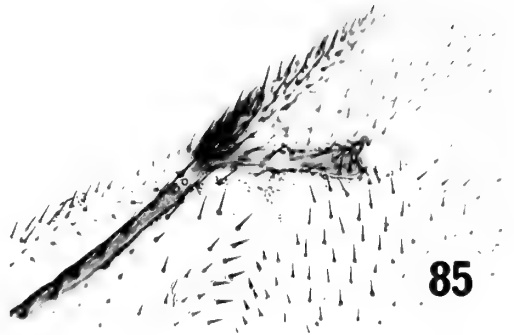


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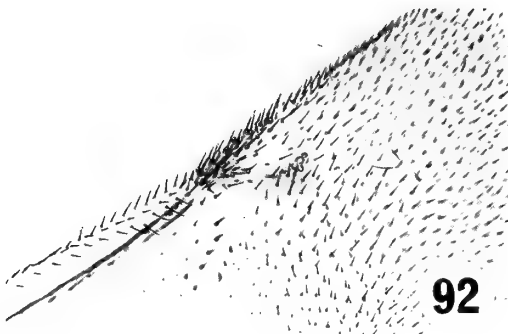
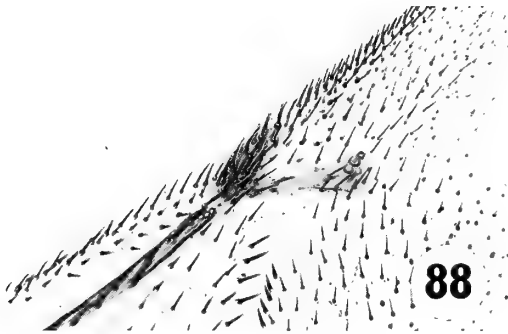


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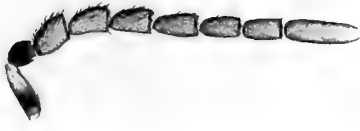
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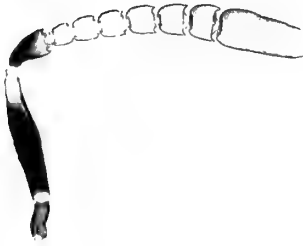
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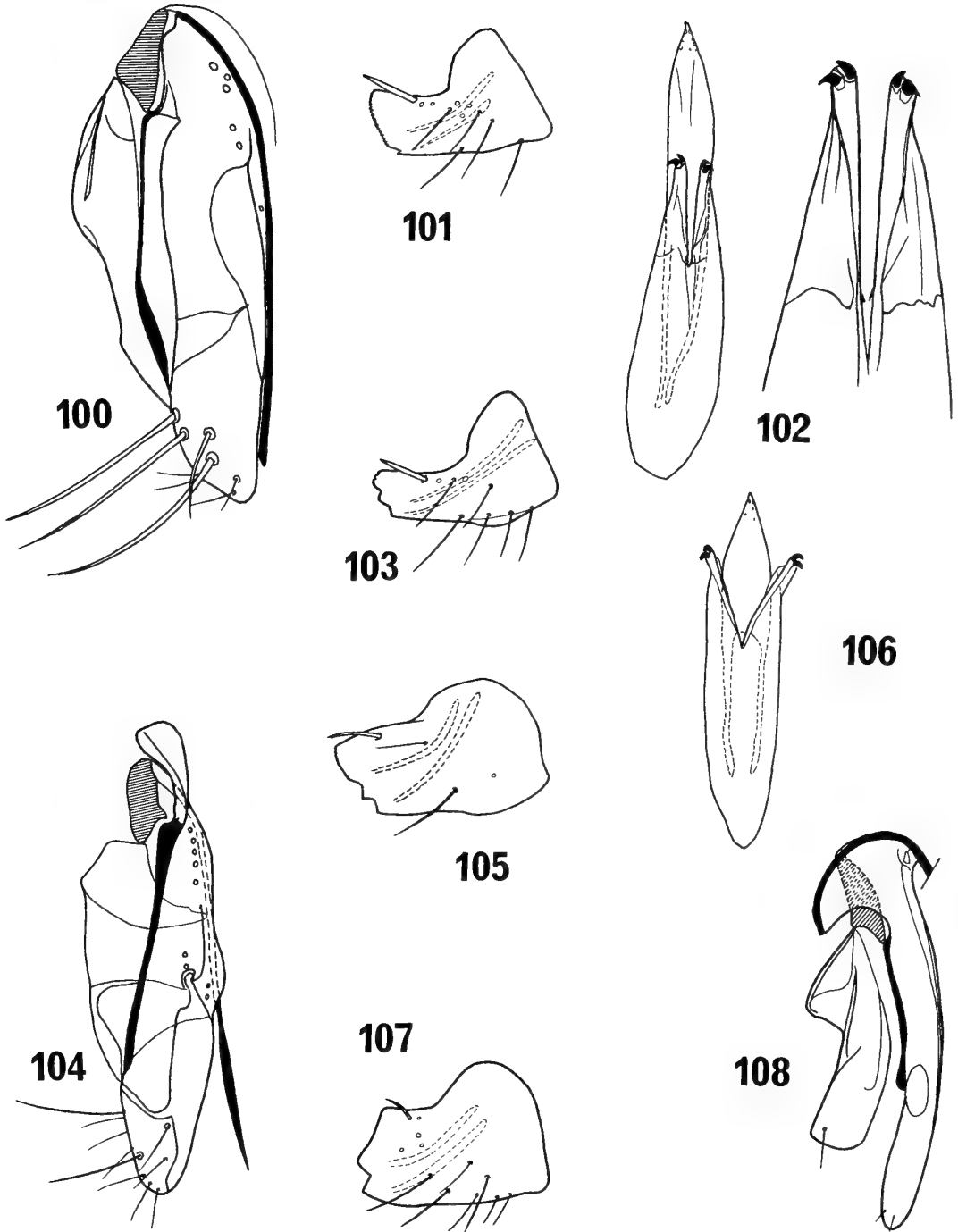


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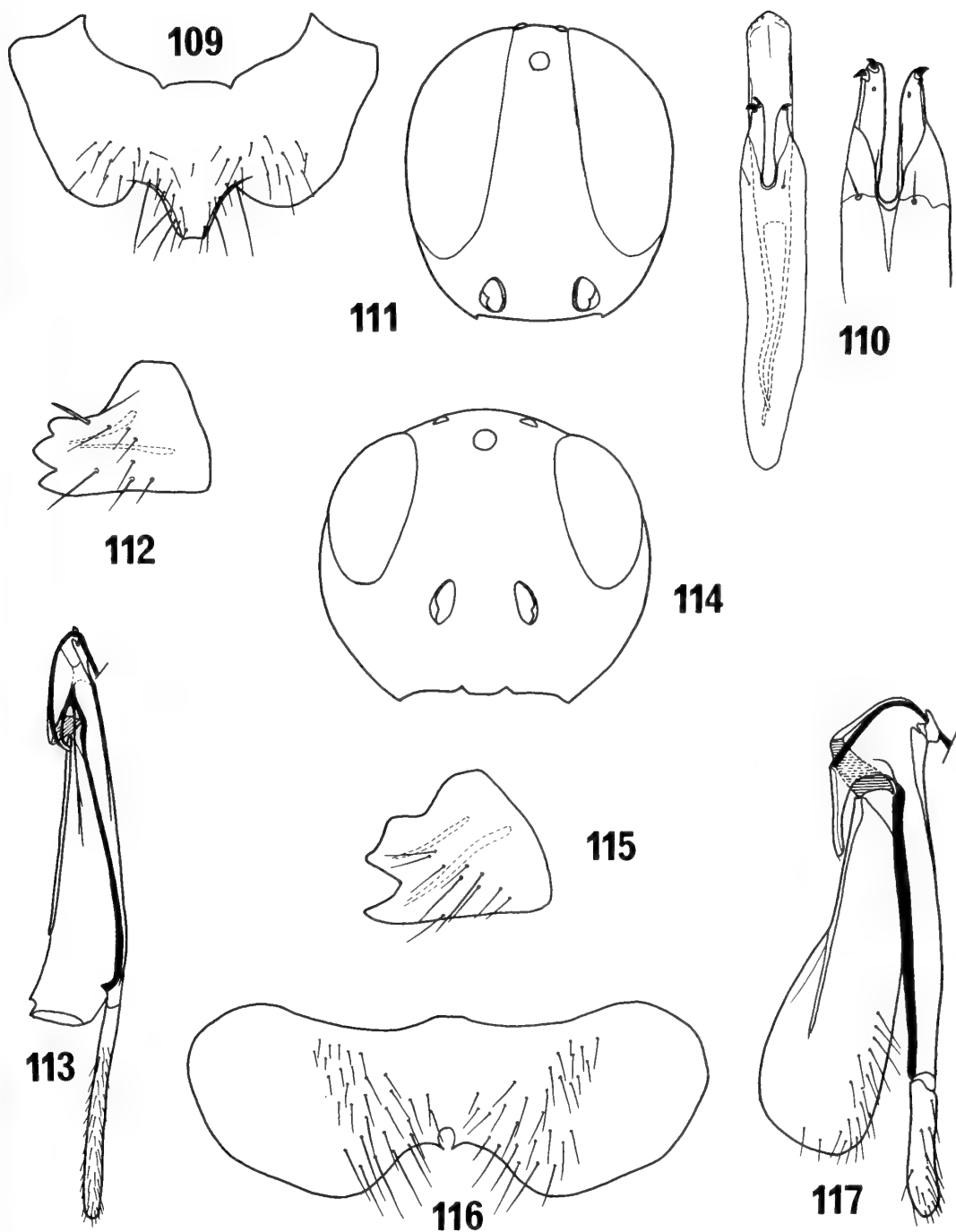


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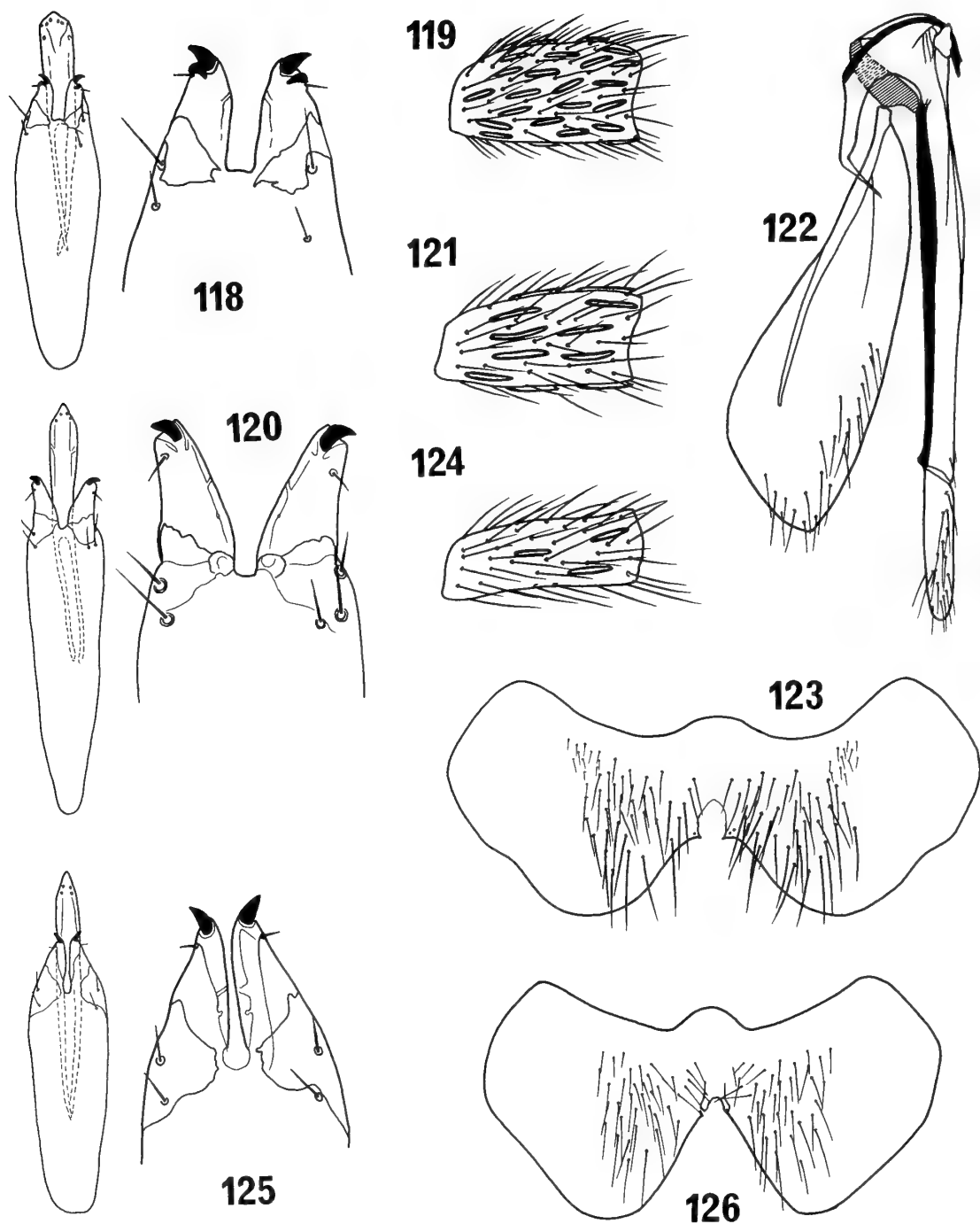
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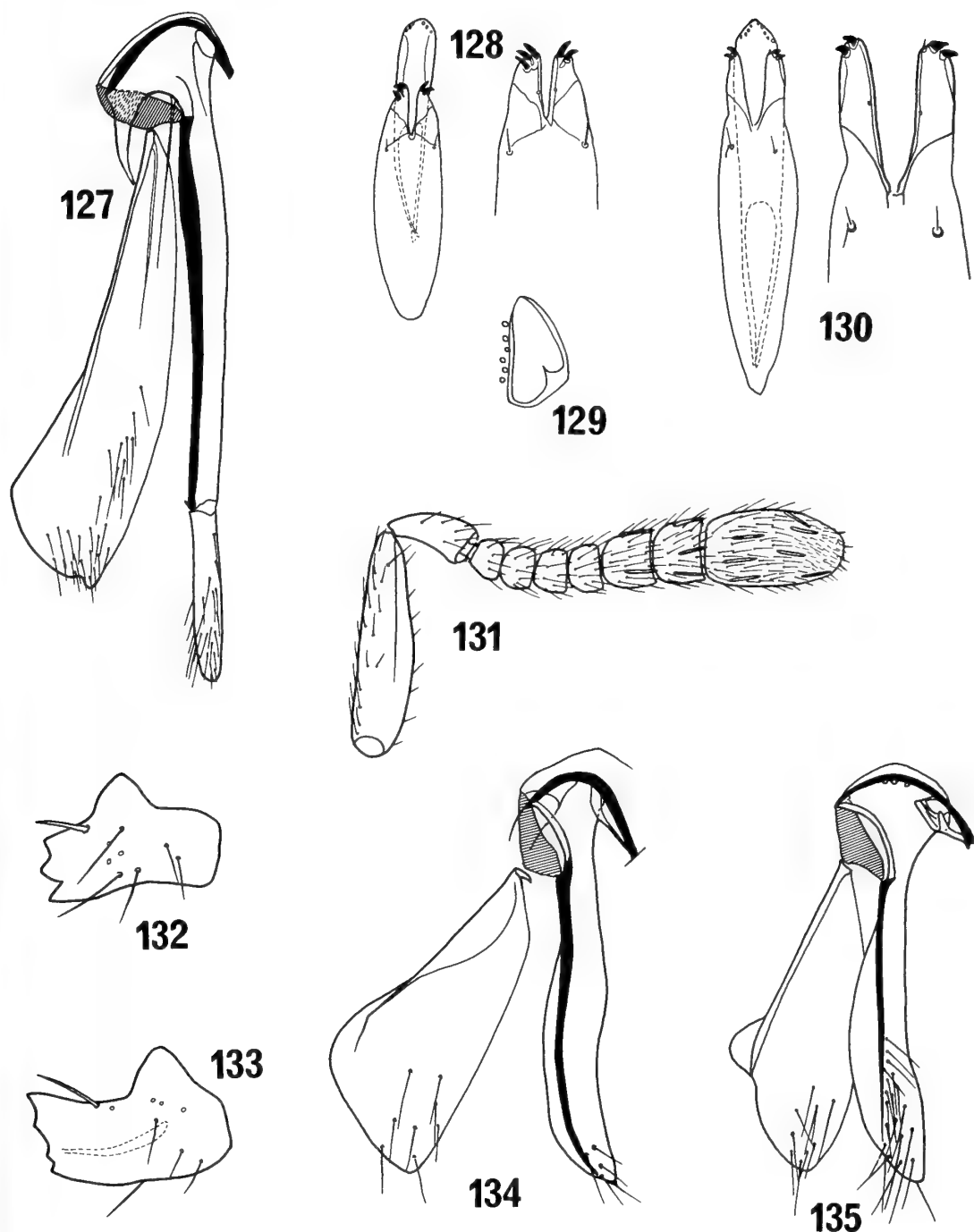
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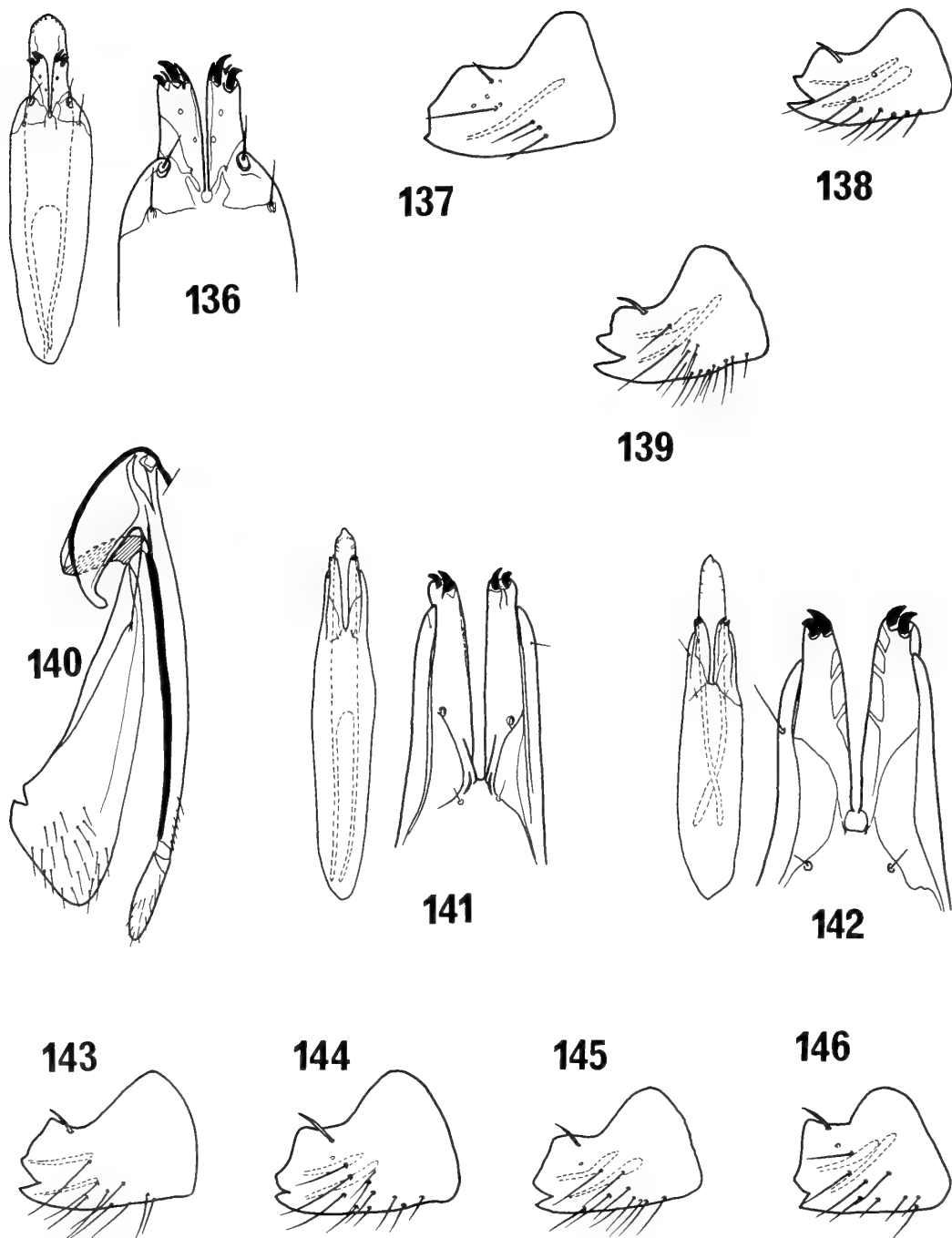
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